Stratigraphic correlations between the continental and marine Tethyan and Peri-Tethyan basins during the Late Carboniferous and the Early Permian

Alain IZART [1], Denis VASLET [2], Céline BRIAND [1], Jean BROUTIN [3], Robert COQUEL [4], Vladimir DAVYDOV [5], Martin DONSIMONI [2], Mohammed El WARTITI [6], Talgat ENSEPBAEV [7], Mark GELUK [8], Nathalya GOREVA [9], Naci GÖRÜR [10], Nayyer IQBAL [11], Geroi JOLTAEV [7], Olga KOSSOVAYA [12], Karl KRAINER [13], Jean-Pierre LAVEINE [4], Maria MAKHLINA [14], Alexander MASLO [15], Tamara NEMIROVSKAYA [15], Mahmoud KORA [16], Raissa KOZITSKAYA [15], Dominique MASSA [17], Daniel MERCIER [18], Olivier MONOD [19], Stanislav OPLUSTIL [20], Jörg SCHNEIDER [21], Hans SCHÖNLAUB [22], Alexander STSCHEGOLEV [15], Peter SÜSS [23], Daniel VACHARD [4], Gian Battista VAI [24], Anna VOZAROVA [25], Tuvia WEISSBROD [26], Albin ZDANOWSKI [27]

(see appendix 2 for addresses)

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ABSTRACT

The compilation of detailed stratigraphic, sedimentologic and paleontologic data resulted in stratigraphic correlations of marine and continental areas outcropping today in the Tethyan and Peri-Tethyan domains: (1) the base of the Moscovian would correspond to the base of the Westphalian C in the Peri-Tethyan domain and to the base of the Westphalian B in the Tethyan domain; (2) the Kasimovian, the Gzhelian and the Orenburgian would correspond in the northern Peri-Tethyan domain and Tethyan domain (Carnic Alps) respectively to the early Stephanian, the late Stephanian and the Autunian *p.p.*, in the southern Peri-Tethyan domain to an undifferentiated time interval. The boundary between the Stephanian and the Autunian was recognized in the Donets Basin with some doubts; (3) the Asselian, Sakmarian, Artinskian and Kungurian would correspond in all the domains to the Autunian *p.p.* and the Saxonian that remain difficult to separate.

KEY WORDS
Peri-Tethys,
biostratigraphy,
Carboniferous,
Permian,
Tethys,
stratigraphic correlations.

RÉSUMÉ

Corrélations stratigraphiques dans les bassins téthysiens et péri-téthysiens au Carbonifère supérieur et au Permien inférieur. Des corrélations sont proposées entre les domaines marins et continentaux du Paléozoïque supérieur affleurant aujourd'hui dans le domaine téthysien et sur les plate-formes qui le bordent au nord et au sud: (1) la base du Moscovien correspondrait dans le domaine péri-téthysien à la base du Westphalien C et dans le domaine téthysien à la base du Westphalien B ; (2) le Kasimovien, le Gzhélien et l'Orenburgien correspondraient dans le domaine nord péri-téthysien et dans le domaine téthysien (Alpes carniques) respectivement au Stéphanien inférieur, supérieur et Autunien *p.p.*, dans le domaine sud péri-téthysien à un intervalle de temps indifférencié, la correspondance n'étant pas établie précisément. La limite entre le Stéphanien et l'Autunien a été reconnue dans le bassin du Donetz avec incertitudes ; (3) l'Assélien, le Sakmarien, l'Artinskien, le Kungurien correspondraient dans tous les domaines à l'Autunien *p.p.* et au Saxonien, qui restent difficile à différencier.

MOTS CLÉS
Péri-Téthys,
biostratigraphie,
Carbonifère,
Permien,
Téthys,
corrélations stratigraphiques.

INTRODUCTION

In the frame of the IGCP 343, a synthesis of the published and original data from eastern and western Europe, northern Africa and Arabia is presented. Three litho- and chronostratigraphic cross-sections (location Fig. 1) show the results in three domains outcropping nowadays in the northern Peri-Tethyan domain (Fig. 2, Inset Fig. 1), in the Tethyan domain (Fig. 3, Inset Fig. 2) and in the southern Peri-Tethyan domain (Fig. 4, Inset Fig. 3). Biostratigraphic correlations are proposed in the northern Peri-Tethyan domain (Fig. 5) between the marine eastern basins (Russia, Ukraine) and the continental western basins (France, Germany), and are extended to the other domains (Figs 6, 7). Moreover, the latitudinal correlations between the continental basins and the correlations based on the sequence stratigraphy allow to test the climatic, eustatic and tectonic factors. The radiochronologic data chart of Hess & Lippolt (1986) and of Menning (1995) are chosen for the Late Carboniferous and for the Permian respectively.

BIOSTRATIGRAPHIC CORRELATIONS BETWEEN THE MARINE AND CONTINENTAL DOMAINS

Correlations are proposed for the Bashkirian-Moscovian and Namurian-Westphalian time intervals in the northern Peri-Tethyan domain (Fig. 8). Sinitsyn *et al.* (1978), Yablokov *et al.* (1978), Aisenverg *et al.* (1978), Makhlina *et al.* (1979), Solovieva (1985), Solovieva *et al.* (1985a, b), Kagarmanov & Donakova (1990), Izart *et al.* (1996), Izart *et al.* (1998), Makhlina *et al.* (1997), Vachard & Maslo (1996), Einoir *et al.* (1996), Briand *et al.* (1998), Zhamoida (in press), Ensepbaev *et al.* (this volume) described the Carboniferous of the Ural, Moscow, Donets and Precaspian (Kazakhstan) Basins. The Bashkirian and Moscovian show thin and medium bedded limestones in the Moscow and Ural Basins. During this time, the Donets was a paralic basin with thick alternations of fluvial sandstone, paleosol, coal, marine limestone and claystone, deltaic siltstone and sandstone. In eastern Europe, fusulinid, conodont and coral

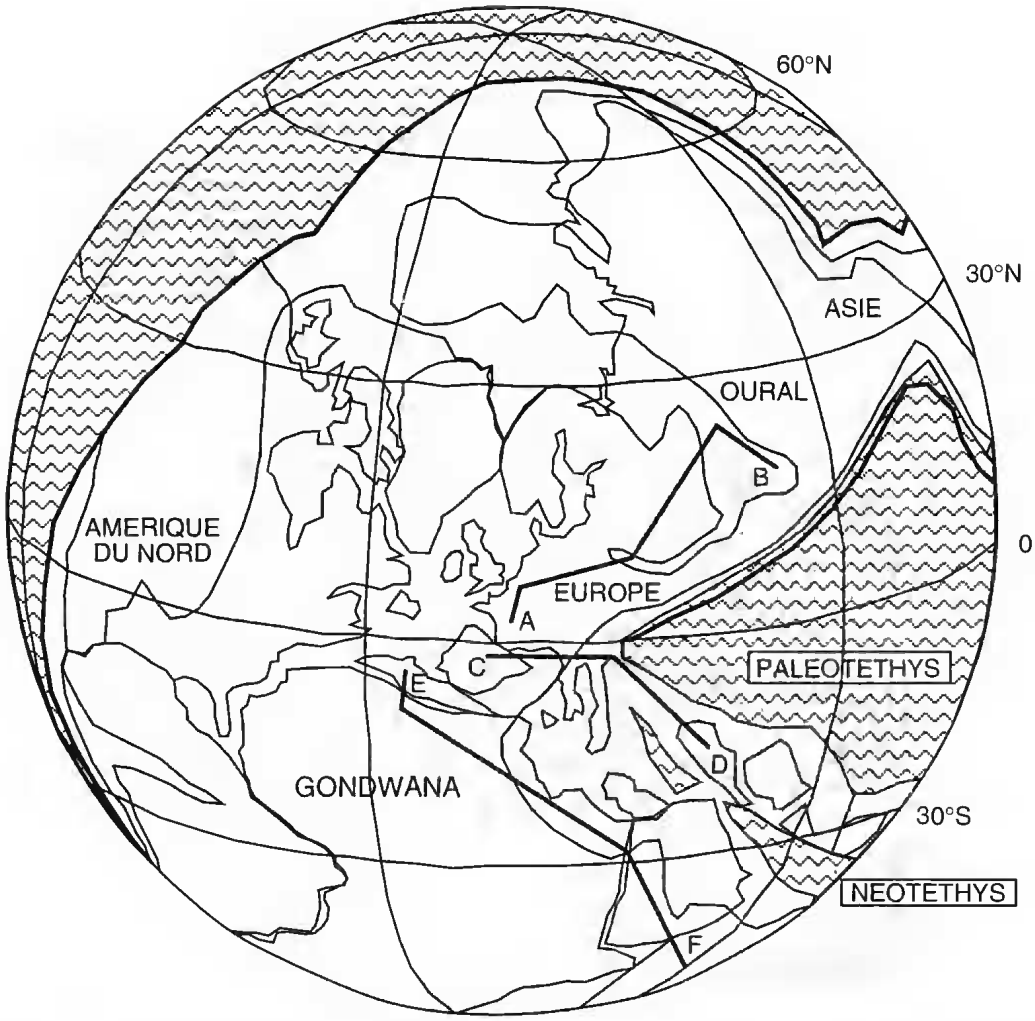


FIG. 1. — Location of cross-sections on the paleogeographic map of the North Hemisphere during the Lower Permian modified after Scotese & Langford (1995). Land in white, shallow sea in stipple, ocean in waves, active plate boundaries in bold lines. **AB**, cross-section of the northern Peri-Tethyan Basins; **CD**, cross-section of the Tethyan Basins; **EF**, cross-section of the southern Peri-Tethyan Basins.

biozones were defined for the Bashkirian, Moscovian, Kasimovian, Gzhelian and marine Early Permian (Fig. 5). See also for the fusulinids, Davydov (1996) and the table in Krainer & Davydov (this volume) and for the corals Kossovaya (1996) and Kossovaya (this volume). In the paralic basins of western Europe, the Namurian and the Westphalian present thick alternations of fluvial sandstone, paleosol, coal, marine, lagoonal and lacustrine claystone, deltaic siltstone and sandstone. The flora allows to define a biostratigraphy and a chronostratigraphy framework (Fig. 5). The distribution of flora for the North France coal basin (Laveine 1987) and microflora for western Europe (Clayton *et al.* 1977) are presented for the Namurian and Westphalian. The basins of Lorraine (Donsimoni 1981), the Netherlands (Geluk), the Ruhr (Fiebig 1969; Josten 1991), Poland (Zdanowski & Zakowa 1995), the Czech (Oplustil & Pesek this volume) and Slovak (Vozarova this volume) Republics, the Caucasus (Chernyavsky *et al.*

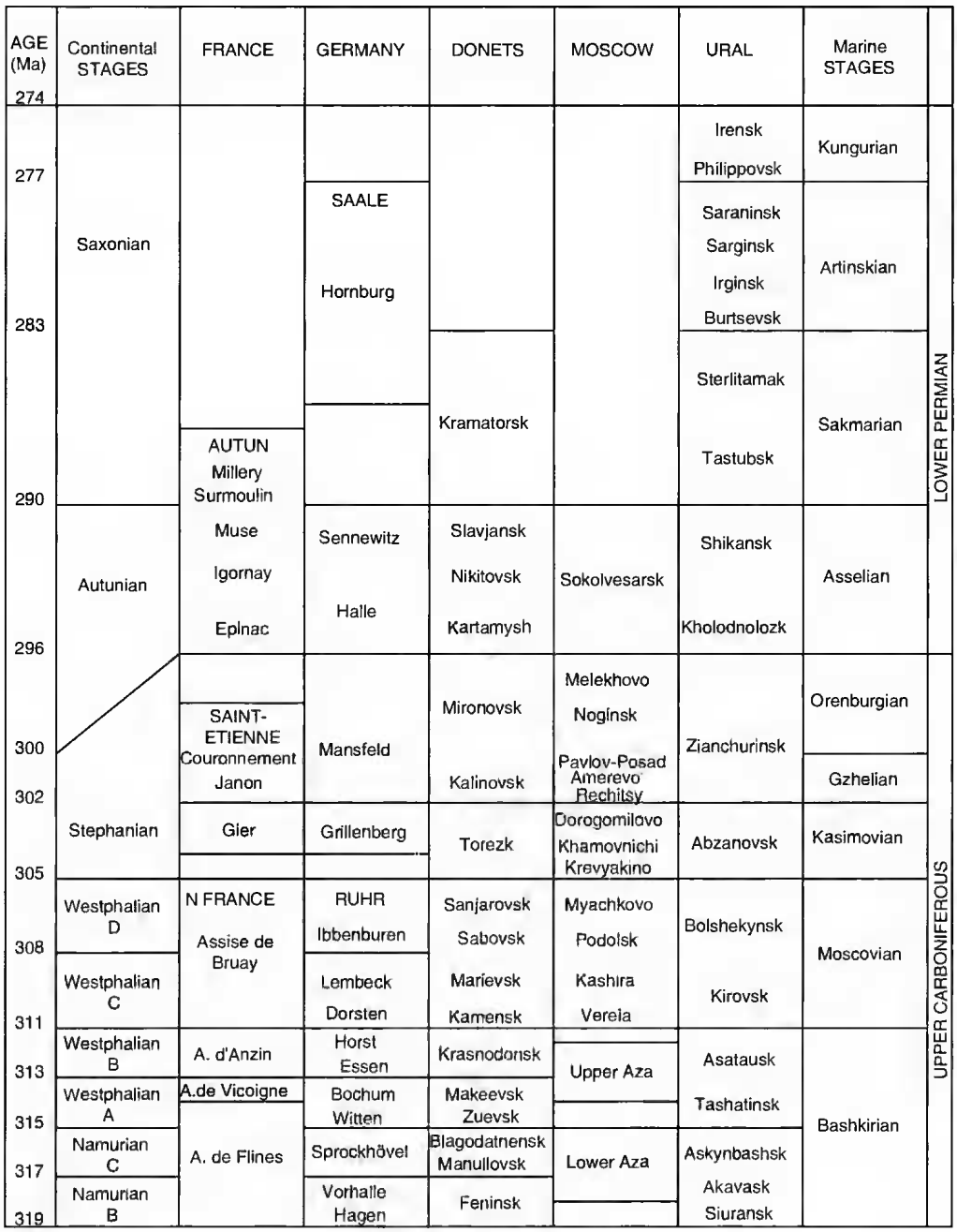


FIG. 2. — The formations of the northern Peri-Tethyan Basins.

1978) and North Turkey (Zonguldak; Kerey *et al.* 1985; Görur *et al.* 1997) are also considered in this study. The Donets Basin is the only northern Peri-Tethyan Basin, where the correlation between the marine and continental domains has been attempted. In this basin, the

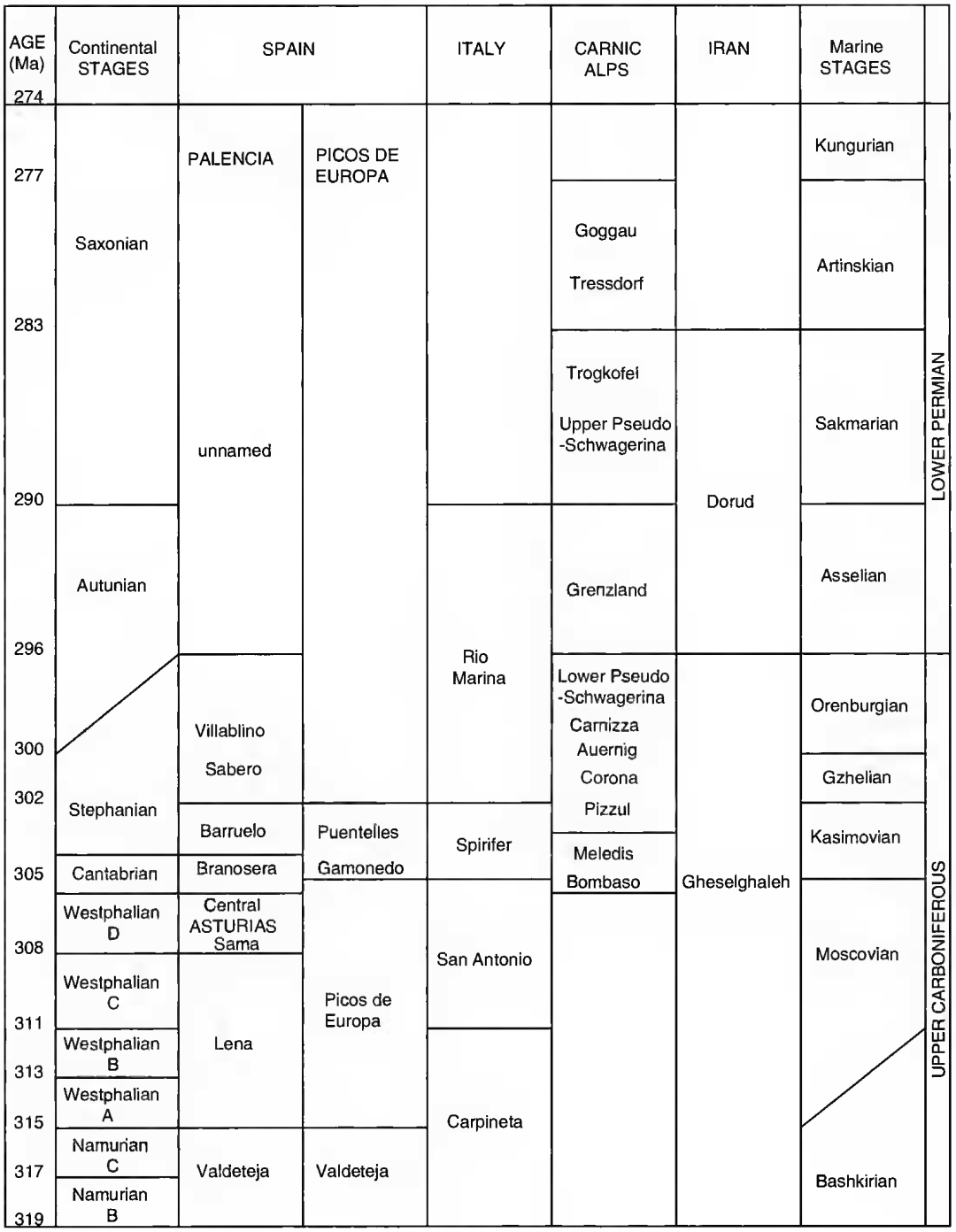


FIG. 3. — The formations of the Tethyan Basins.

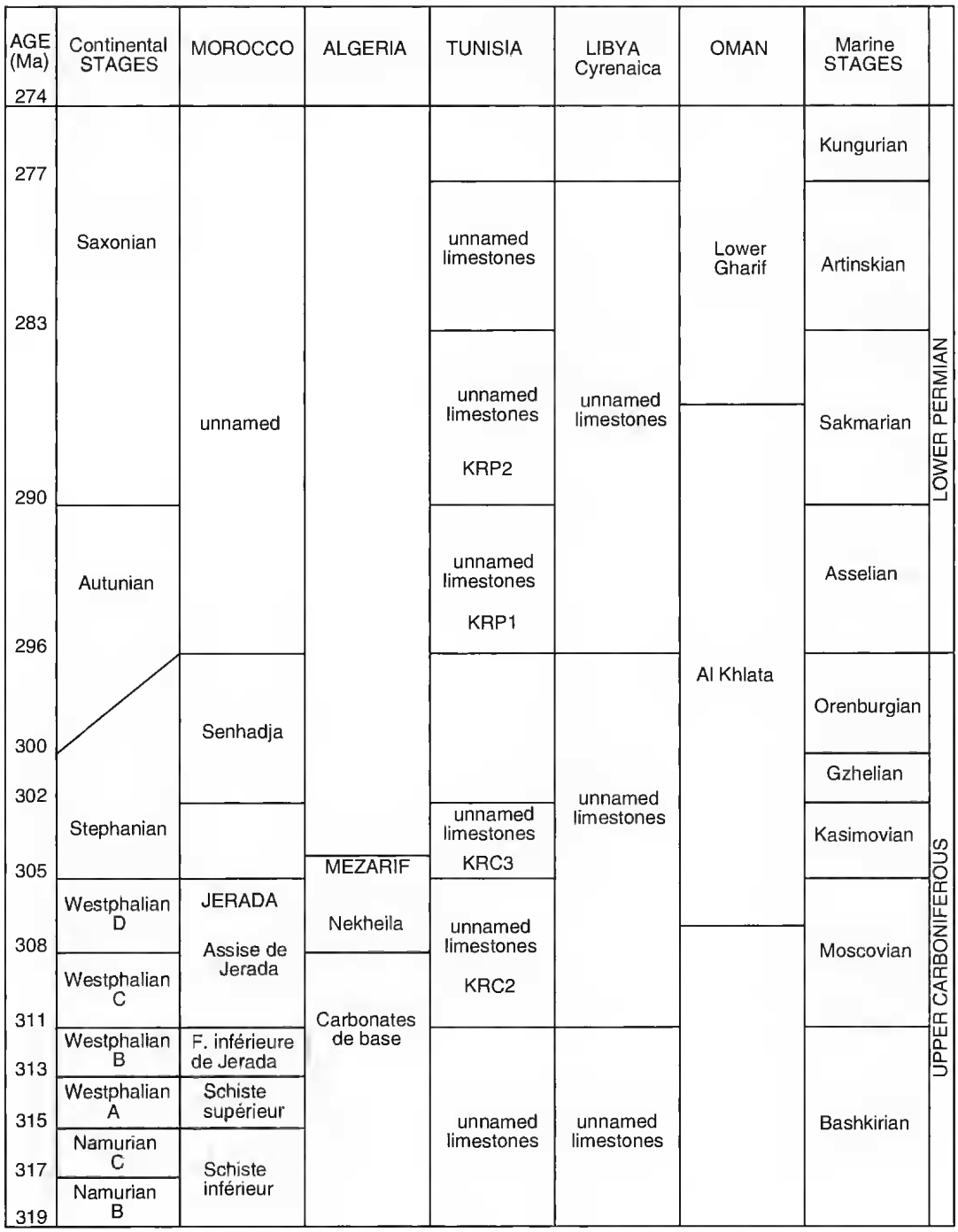
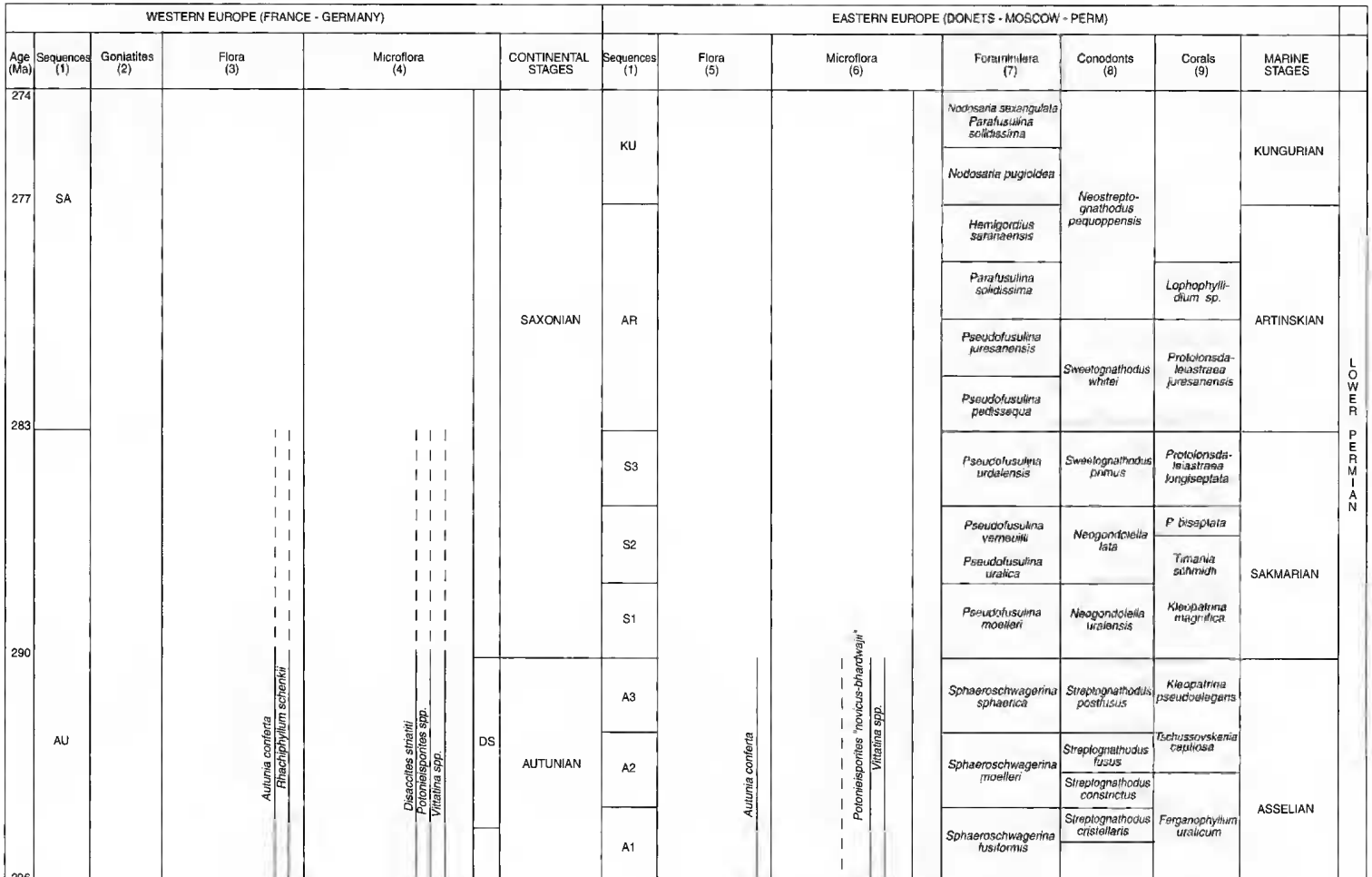


FIG. 4. — The formations of the southern Peri-Tethyan Basins.

flora are closed to western Europe ones (Fissunenko & Laveine 1984), but some differences could be sometimes noted. The microflora presents a local biozonation (Coquel *et al.* 1984). At the boundary between the Westphalian B and C, a disharmony is observed in the appearance of species more precocious or later in the Donets Basin than in western Europe. The base of the Moscovian would be inside the Westphalian B or at the base of the Westphalian C (Fig. 8).

Correlations are proposed for the Kasimovian-Gzhelian-Orenburgian and the Stephanian-Autunian in the northern Peri-Tethyan domain. The Kasimovian, the Gzhelian and the Orenburgian show thin limestones in the Moscow Basin and thick paralic facies in the Donets Basin. The Kasimovian, the Gzhelian and the Orenburgian (Fig. 5) present fusulinid, conodont and coral biozones in the Moscow, Ural and Donets Basins. Davydov (1990, 1992) moved the *Ultradaixina bosbytauensis* biozone from the Asselian to the late Gzhelian. The boundaries of this biozone present an uncertainty, because Davydov defined this biozone in the carbonated marine facies of the pre-Donets Basin in Russia, whereas the Donets Basin in Ukraine shows lagoonal facies without fusulinids. Then, Davydov (1996) put the *Daixina sokensis* and *Ultradaixina bosbytauensis* biozones in the Orenburgian, between the Gzhelian and the Asselian. The boundary between the Carboniferous and the Permian is located at the top of the Orenburgian. The Stephanian, defined in the limnic basin of Saint-Étienne, was subdivided by Doubinger *et al.* (1995) into a early Stephanian (Barruelian) corresponding to the Stephanian A and an late Stephanian (Forezian) corresponding to the Stephanian B and C with a precise biozonation of flora (Fig. 5). The Stephanian presents breccia along the sides of the basin and lacustrine claystone and coal in the center (Becq-Giraudon *et al.* 1995, Mercier this paper). The early Stephanian exhibits hygrophytic Lycophytes and Filicophytes (*Pecopteris* sp., *Asterotheca lamuriana*, Fig. 5) and presents Westphalian affinities. The late Stephanian shows hygrophytic Pteridosperma-phytes and Lycophytes (*Odontopteris* sp., *Pecopteris* sp., *Sphenopteris* sp., *Alethopteris zeilleri, Sphenophyllum angustifolium*) and some occurrences of xerophytic plants (*Autunia conferta, Lodevia nicklesii*). The biozonation of Clayton *et al.* (1977) applies in Saint-Étienne with some occurrences of xerophytic spores with *Potonieisporites novicus* and *Vittatina* sp. Alternation of hygrophytic and xerophytic floras and microfloras are observed through the late Stephanian in numerous basins (Broutin *et al.* 1986, 1990). The basins of Lorraine (Donsimoni 1981), the Saale (Schneidert & Gebhardt 1993), Poland (Zdanowski, this paper), the Czech (Oplustil this paper) and Slovak (Vozarova this paper) Republics, the Caucasus (Chernyavsky *et al.* 1978) and North Turkey (Kerey *et al.* 1985) are also considered. In the Donets Basin (Fig. 8), the biozonation of flora is local (Boyarina, in press; Izart *et al.* 1998) with some common plants as *Asterotheca lamuriana* in the late Stephanian. There were alternations of hygrophytic and xerophytic flora and microflora (*Lodevia nicklesii, Potonieisporites novicus*) in the Orenburgian (Stschegolev *in* Aisenverg *et al.* 1978; Stschegolev & Kozitskaya 1984; Izart *et al.* 1998). The Kasimovian (Fig. 8) would be equivalent to the early Stephanian. The Gzhelian (Fig. 8) would be the equivalent of the late Stephanian, the Orenburgian of the early Autunian *p.p.* if we refer to the appearance of the xerophytic plants, or of the late Stephanian if we refer to the acme of the xerophyric plants. The beginning of the sedimentation in the Stephanian and Autunian Basins that depends on their tectonic opening will be heterochronous in western Europe.

Correlations are proposed between the marine and continental Early Permian in the northern Peri-Tethyan domain. The marine Early Permian was defined in the Ural Basin (Chuvashov 1993). The Asselian, the Sakmarian, the Artinskian Stages have a carbonate facies whereas the Kungurian is evaporitic. Biozones of fusulinids, conodonts and corals were defined (Fig. 8). The new Permian chronostratigraphic subdivisions (Yugan 1996; Yugan *et al.* 1997) were utilized. In the Moscow Basin, the Asselian is carbonated and in the Donets Basin, the Asselian and the Sakmarian exhibit red claystone and evaporites. The Autunian, defined in the limnic basin of Autun (Fig. 5), shows fluvial sandstone and


WESTERN EUROPE (FRANCE - GERMANY)
EASTERN EUROPE (DONETS - MOSCOW - PERM)
Age (Ma)
Sequences (1)
Goniatites (2)
Flora (3)
Microflora (4)
CONTINENTAL STAGES
Sequences (1)
Flora (5)
Microflora (6)
Foraminifera (7)
Conodonts (8)
Corals (9)
MARINE STAGES
274
277
283
290
296
SA
AU
Autunia conferta
Rhachiphyllum schenkii
Disaccites striatiti
Potonieisporites spp.
Vittatina spp.
DS
SAXONIAN
AUTUNIAN
KU
AR
S3
S2
S1
A3
A2
A1
Autunia conferta
Potonieisporites "novicus-bharadwaji"
Vittatina spp.
Nodosaria sexangulata
Parafusulina solidissima
Nodosaria pugioidea
Hemigordius saranaensis
Parafusulina solidissima
Pseudofusulina juresanensis
Pseudofusulina pedissequa
Pseudofusulina urdalensis
Pseudofusulina vermeuili
Pseudofusulina uralica
Pseudofusulina moelleri
Sphaeroschwagerina sphaerica
Sphaeroschwagerina moelleri
Sphaeroschwagerina fusiformis
Neostrepto-gnathodus pequoppensis
Sweetognathodus whitei
Sweetognathodus primus
Neogondolella lata
Neogondolella uraiensis
Streptognathodus postfusus
Streptognathodus fusus
Streptognathodus constrictus
Streptognathodus cristellaris
Lophophyllidium sp.
Protolonsdaleiastraea juresanensis
Protolonsdaleiastraea longiseptata
P. bisaptata
Timania schmidti
Kleopatrina magnifica
Kleopatrina pseudoelegans
Tschussovskenia capitosa
Fenganophyllum uralicum
KUNGURIAN
ARTINSKIAN
SAKMARIAN
ASSELIAN
LOWER PERMIAN

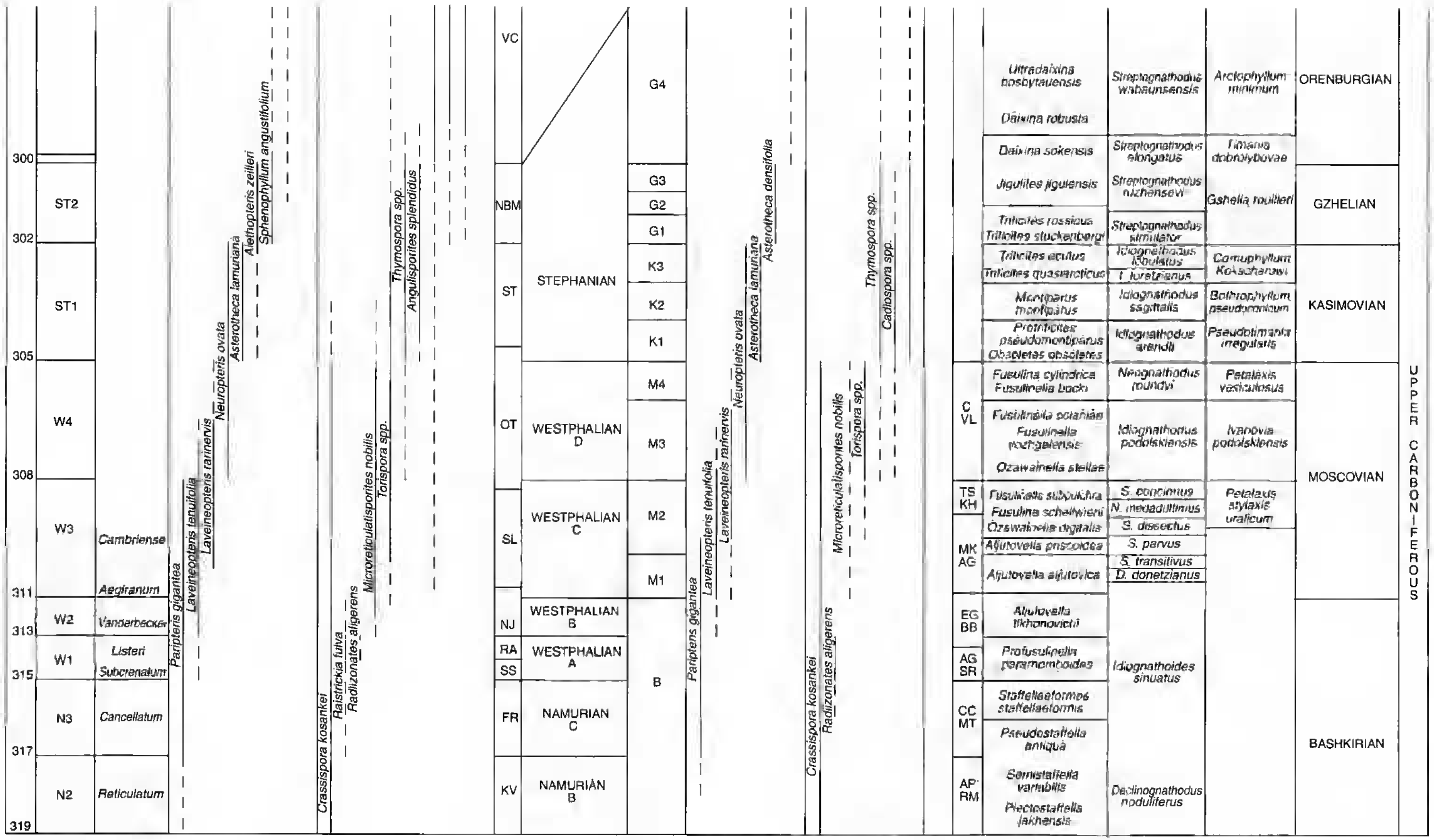


FIG. 5. — Biostratigraphy and chronostratigraphy of the northern Peri-Tethyan Basins. 1, Izart (this paper); 2, Bouroz *et al.* (1978); 3, Laveine (1987), Broutin (this paper); 4, Clayton *et al.* (1977), Coquel & Broutin (this paper); 5, Fissunenko & Laveine (1984), Stschegolev & Broutin (this paper); 6, Coquel *et al.* (1984), Inosova *et al.* (1976), Broutin (this paper); 7, Solovieva *et al.* (1985a, b), Davydov (1990, 1992), Chuvashov (1993), Vachard & Maslo (this paper); 8, Alekseev, Goreva, Kozitskaya & Nemirovskaya (this paper); 9, Kossovaya (this paper).

SPAIN (PALENCIA-CENTRAL ASTURIAS)							SPAIN (PICOS DE EUROPA)			CARNIC ALPS				
Age (Ma)	Sequences (1)	Flora (2)	Microflora (3)	CONTINENTAL STAGES	Foraminifera (4)	MARINE STAGES	Sequences (1)	Foraminifera (5)	MARINE STAGES	Sequences (1)	Foraminifera (6)	Flora (7)	MARINE STAGES	
274													KUNGURIAN	LOWER PERMIAN
277	SA	*Autunia conferta*		SAXONIAN							*Schwagerina vulgaris*		ARTINSKIAN	
283											*Praeparafusulina lutugini*			
										S	*Paraschwagerina inflata*		SAKMARIAN	
290	AU			AUTUNIAN						A	*Schwagerina moelleri*	*Autunia conferta*	ASSELIAN	
											Sphaeroschwagerina glomerosa			
296														

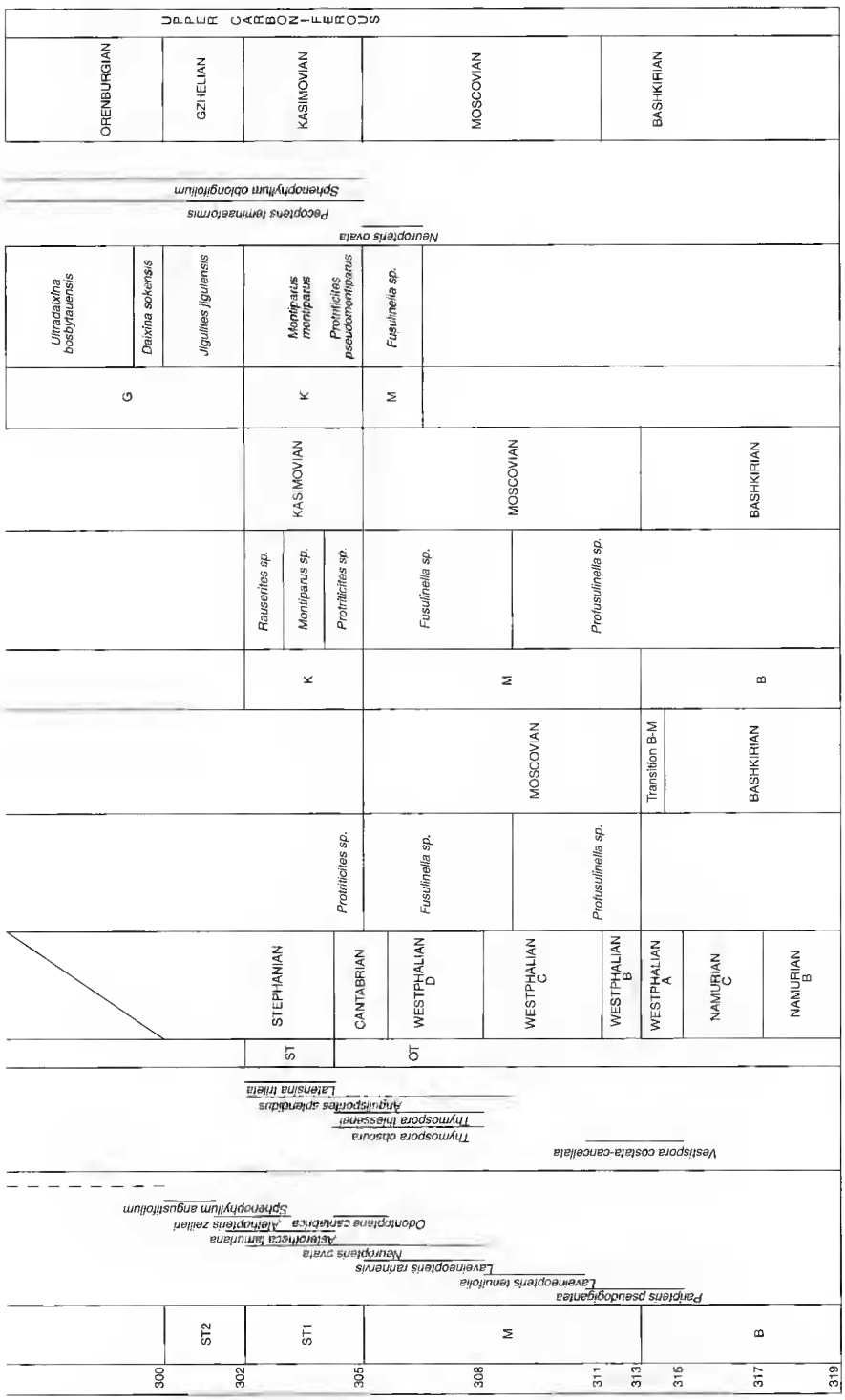


FIG. 6. — Biostratigraphy and chronostratigraphy of the Tethyan Basins. **1**, Izart (this paper); **2**, Wagner & Winkler-Prins (1985), Martinez Garcia (1991); **3**, Leyva *et al.* (1985), Coquel & Rodriguez (1995); **4**, Lys (1988), Granados *et al.* (1985); **5**, Villa (this paper); **6**, Krainer (1992, 1993), Vai & Venturini (1997); **7**, Krainer (this paper).

MOROCCO - ALGERIA - TUNISIA - LIBYA - EGYPT									SAUDI ARABIA		OMAN		
Age (Ma)	Sequences (1)	Goniatites (2)	Flora (3)	Microflora (4)	CONTINENTAL STAGES	Sequences (1)	Foraminifera (5)	MARINE STAGES	Sequences (1)	Microflora of Arabia (6)	Microflora of Oman (7)	STAGES	
274								KUNGURIAN				KUNGURIAN	LOWER PERMIAN
277					SAXONIAN								
	SA							ARTINSKIAN				ARTINSKIAN	
283			*Lodevia nicklesii*	*Potonieisporites "novicus bhardwaji"*							*Kingiacolpites subcircularis*		
			Rhachiphyllum schenkii	*Vittatina spp.*		S	*Schwagerina sp.*	SAKMARIAN	S			SAKMARIAN	
290							*Staffellidae*				*Cycadopites cymbatus*		
	AU				AUTUNIAN	A	*Sphaeroschwagerina sp.*	ASSELIAN	A		*Protohaploxypinus spp.*	ASSELIAN	
296											*Vittatina spp.*		

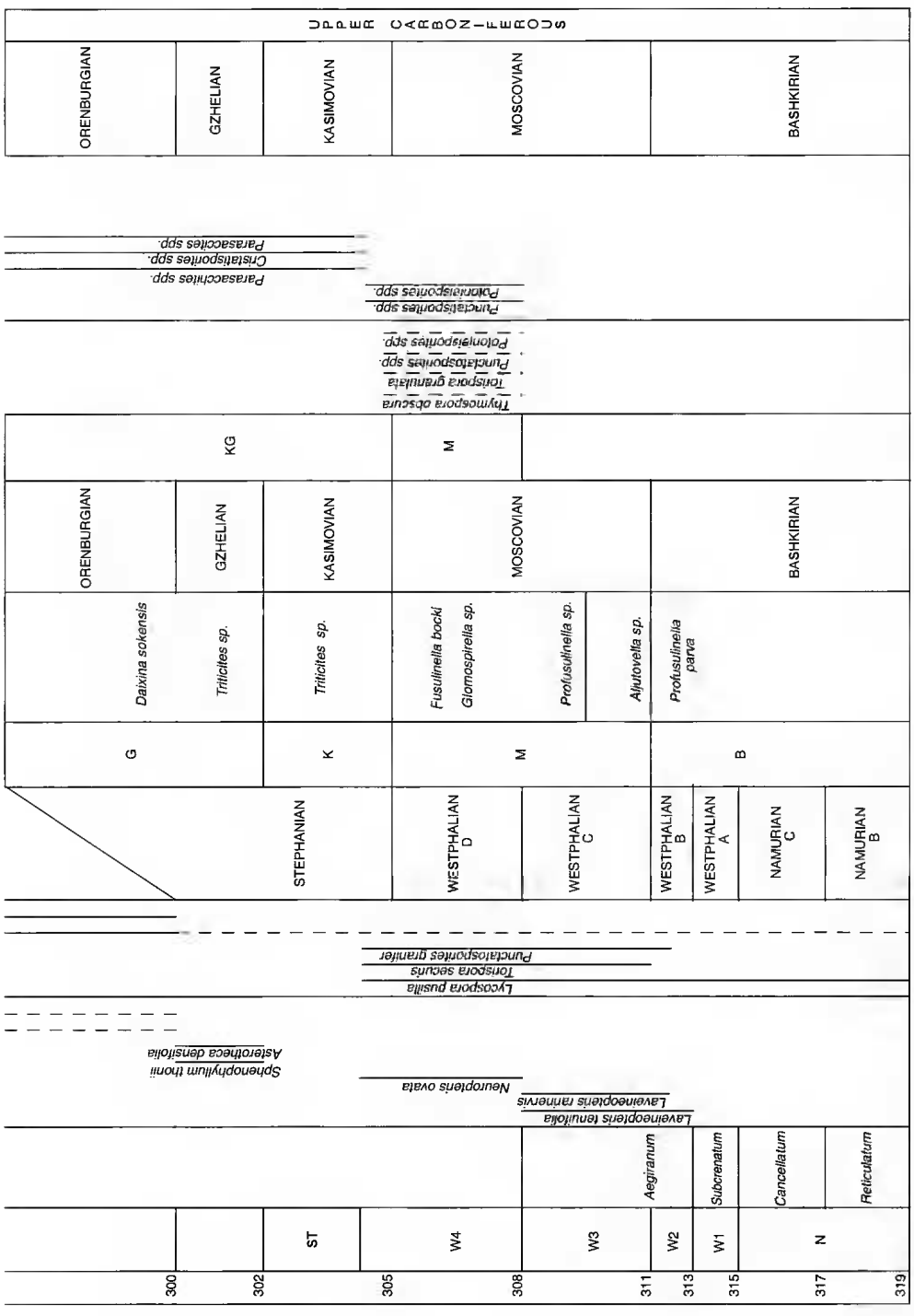
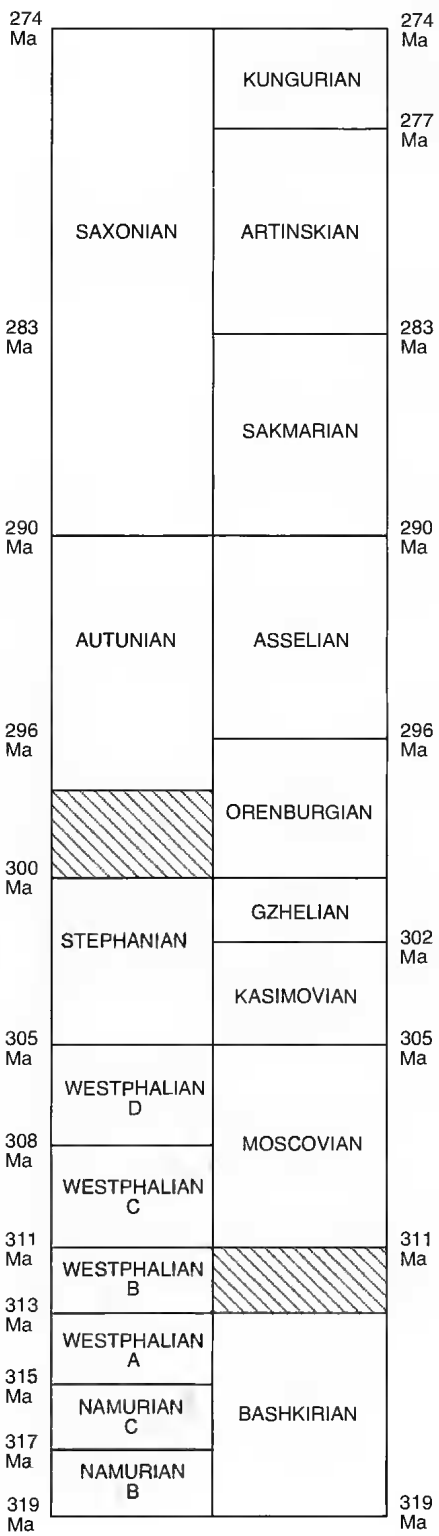


FIG. 7. — Biostratigraphy and chronostratigraphy of the southern Peri-Tethyan Basins. **1**, Izart (this paper); **2**, Deleau (1951), Owodenko (1976); **3**, Deleau (1951), Nedjari (1982), Desteucq *et al.* (1988), Broutin & El Wartiti (this paper); Aassoumi (1994); **4**, Doubinger & Fabre (1983), Aassoumi (1994); **5**, Lys (1988), Nedjari (1982), Massa & Vachard (1979), Kora (this paper); **6**, Owens & Turner (1995); **7**, Love (1994).



lacustrine claystone with xerophytic flora and microflora (*Autunia conferta*, *Rhachiphyllum schenkii*, *Potonieisporites* sp., *Vittatina* sp.). The Saar-Nahe Basin presents red fluvial sandstone and lacustrine black shale (Stapf 1997). The Saale Basin in Germany (Schneider & Gebhardt 1993; Schneider *et al.* 1994, 1995; Schneider 1996; Schneider & Rössler in press) exhibits two informal lithological units named early and late "Rotliegend". The early "Rotliegend" includes grey conglomerates and sandstones that would be dated to the Autunian by plants (*Autunia conferta*) and the late "Rotliegend" red conglomerates and sandstones that would be dated to the Saxonian by tracks of reptile. The boundary of these units presents an incertitude between the basins of North Germany and the Saale (Menning 1995). The basins of Poland (Zdanowski this paper), the Czech (Oplustil this paper) and Slovak (Vozarova this paper) Republics are also considered. In the Donets Basin (Fig. 5), the flora and microflora of the Asselian and Sakmarian Stages are xerophytic (Inosova *et al.* 1976) with *Autunia conferta*, *Potonieisporites* sp. and *Vittatina* sp. The climate changed from a humid tropical to a dry tropical climate (Parrish 1995). According to Schneider *et al.* (1994, 1995), the Kartamysh, Nikitovsk and Slavjansk formations would be equivalent to the early "Rotliegend" and the Kramatorsk formation to the late "Rotliegend" with some incertitudes. The Asselian would correspond to the Autunian *p.p.* and the Sakmarian, Artinskian and Kungurian to the Saxonian (Fig. 8).

Correlations are proposed in the Tethyan (Fig. 6) and southern Peri-Tethyan domains (Fig. 7). The Bashkirian and Moscovian are dated by fusulinids in the paralic basin of the Cantabrian zone in Palencia (Lys 1988a) and in the central Asturias (Granados *et al.* 1985), the limestones of the Picos de Europa (Villa 1985; Villa *et al.* 1993), Tuscany (Vai 1991, 1994; Pasini & Vai 1997), eastern Elbourz (Jenny *et al.* 1978; Jenny-Deshusses 1983), Mezarif, Algeria (Nedjari

FIG. 8. — Correlations of the continental and marine Late Carboniferous and Early Permian of the Tethyan and Peri-Tethyan Basins. Oblique lines: uncertainty.

1982; Lys 1988a), Tunisia (Lys 1988b), Turkey (Monod 1977; Lys 1988a), Libya (Massa & Vachard 1979; Vachard *et al.* 1993), Egypt (Kora 1995), Syria (Al Youssef & Ayed 1992). The Carnic Alps (Schönlaub 1992; Krainer 1993; Vai 1991; Vai & Venturini 1997; Krainer & Davydov, this volume) present only the late Moscovian. Some marine bands dated to the Moscovian are known in Morocco, Jerada (Owodenko 1976) and in Algeria, Bechar (Deleau 1951). The Kasimovian is found everywhere except in Algeria (Bechar, Mezarif). The Gzhelian and the Orenburgian are found everywhere except in Spain, Algeria (Bechar, Mezarif) and southern Tunisia (Lys 1988b). The marine Early Permian is found everywhere except in Spain, Algeria (Bechar, Mezarif) and Libya (Ghadames). The marine facies of the Late Carboniferous and Early Permian are unknown in Saudi Arabia. In Oman, the Early Permian presents marine and continental levels (Broutin *et al.* 1995; Angiolini *et al.* 1997).

The Westphalian is paralic in central Asturias, in Jerada (Morocco) and in Bechar (Algeria). The hygrophytic flora and microflora are dated the Westphalian A to D in central Asturias (Leyva *et al.* 1985a, b, c; Granados *et al.* 1985; Saenz de Santa Maria *et al.* 1985; Wagner & Alvarez 1991) and in Jerada (Owodenko 1976; Desteucq *et al.* 1988; Izart 1991), the Westphalian C and D in Bechar (Deleau 1951; Coquel *et al.* 1988). Elsewhere the base of the Moscovian could be located in Spain inside the Westphalian A or B (Wagner & Bowman 1983; Granados *et al.* 1985; Leyva *et al.* 1985a, b, c; Martinez Dias *et al.* 1985; Ginkel & Villa 1996), and in Algeria at the base of the Westphalian C (Lys 1988a) as in eastern Europe, but there is an objection: an eustatic event is synchronous everywhere in the world, or the appearance of plants in the Westphalian of Spain presents a dishatmony. In Libya (Massa *et al.* 1980; Coquel *et al.* 1988), in Saudi Arabia (Owens & Turner 1995), in Oman (Love 1994) as in Gondwanaland, a xerophytic microflora with *Potonieisporites* sp. is known in the Westphalian D.

In the Cantabrian zone in Palencia, Bouroz *et al.* (1972), Wagner & Winkler-Prins (1985, 1991, 1993) defined the Cantabrian and the Stephanian in the interval attributed by Lys (1988a) to the late Moscovian (Myachkovian) and the Kasimovian. The comparison between the flora and microflora (Coquel & Rodriguez 1995) does not allow to differentiate the Cantabrian and the Stephanian. The precocious tectonic opening of the basin of the Cantabrian zone in Palencia would explain the presence of the Cantabrian in this basin and its absence in the Saint-Étienne Basin. The lower part of the Cantahrian could he connected with the Westphalian D and the upper part with the early Stephanian. In the Carnic Alps, Krainer (1993) reported in the Kasimovian and the Gzhelian hygrophytic flora dated to the Stephanian (*Pecopteris* sp., *Sphenophyllum* sp.). In Morocco, hygrophytic plants dated to the late Stephanian exist in the High Atlas (Beauchamp *et al.* 1986; Doubinger & Roy-Dias 1985, 1986; Aassoumi 1994). In Oman, Love (1994) described microflora *Microbaculispora* known in the Gondwanaland. The equivalence between the Kasimovian-Gzhelian and the Stephanian is established in the Tethyan domain, but not in the southern Peri-Tethyan domain.

The Autunian presents xerophytic plants (*Autunia conferta*) in the Carnic Alps (Krainer 1993) and in Spain where in addition the Saxonian exists (Martinez-Garcia 1991). The Autunian and the Saxonian exhibit xerophytic flora and microflora with *Lodevia nicklesii*, *Rhachiphyllum schenkii*, *Potonieisporites* sp. and *Vittatina* sp. in central Morocco (Broutin *et al.* 1987; El Wartiti *et al.* 1986, 1990; Aassoumi 1994), Doubinger & Fabre (1983) attributed to the Autunian a microflora with *Tarispora* sp., *Potonieisporites* sp. at the top of the Bechar Series. In Oman, Love (1994) distinguished the biozone *Cycadopites* dated to the Asselian and Sakmarian and the biozone *Kingiacolpites* dated to the late Sakmarian to Kungurian, known in Gondwanaland. In the Salt Range (Pakistan), the biozone *Cycadopites* (Iqbal 1993 and this volume) was found at the base of the Warcha Formation, corresponding to the Sakmarian-Artinskian interval. Everywhere, the correlations are imprecise between the marine and continental Permian.

LATITUDINAL CORRELATIONS

The stratigraphic correlations provided by the plants of the continental domain will depend on the latitudinal location of each domain. Following the position of the continents according to Scotese & McKerrow (1990), this hypothesis can be tested on the basis of the relations between the hygrophytic plants and the equatorial-humid tropical climate and between the xerophytic plants and the dry tropical-desert climate. The geographic zonation of climate has been described in term of floral biomes for the Early Permian (Sakmarian) and Late Permian (Kazanian) by Ziegler (1990) and Ziegler *et al.* (1997). The biomes are: (1) equatorial and tropical everwet, (2) tropical and subtropical summerwet, (3) coastal and inland tropical desert, (4) winterwet, (5) western and eastern warm temperate, (6) western and eastern cool temperate, (7) midlatitude desert, (8) cold temperate, (9) arctic and (10) glacial. This approach has been adapted from a climate study of the Recent. The sediments gave also informations about the climates: coal in various climates (cold to tropical), reef in tropical climate, evaporite in dry tropical or desert climate, tillites in cold climate. Numerous paleoclimate studies exist for the Permian: Parrish (1995), Kutzbach & Gallimore (1989), Kutzbach & Ziegler (1993), Barron & Fawcett (1995); Crowell 1995. All these studies exhibit from Late Carboniferous to Trias an increase of the aridity in the humid tropical zone, that was explained by the perfect symmetry of the continental surfaces at the equator, that implied a warm and dry climate with monsoons. In the northern Peri-Tethyan domain, the location of western and eastern Europe was between the equator and 5°N during the Westphalian, between 5°N and 10°N during the Early Permian (Fig. 1). All the basins were located inside the same latitudinal zone and the latitudinal correlations are excellent. The Westphalian presents hygrophytic plants and coal in the everwet biome, the Stephanian alternation of hygrophytic and xerophytic plants (Saint-Étienne, Saale, Donets) and alternation of red beds and grey beds with coal (Lorraine, Saale, Czech Republic, Slovakia, Donets) explained by period of monsoon in the summerwet biome. The Autunian exhibits xerophytic plants growing on the slopes of basins and alternation of red beds and lacustrine black shale (Autun, Lorraine, Saar-Nahe, Saale, Czech Republic and Slovakia) or coal (Donets) in the summetwet biome. The Saxonian presents xerophytic plants, red beds, calcretes and evaporites (Saale, Czech Republic, Slovakia, Donets, Russian platform) in the subtropical desert biome.

In the Tethyan domain (Fig. 1), Spain, Italy and the Carnic Alps were located at 5°S during the Westphalian and Stephanian and at the equator during the Early Permian. The Westphalian and Stephanian present hygrophytic plants and coal in the everwet biome, the Autunian xerophytic plants growing on the slopes of basins and red beds in the summerwet biome, the Saxonian xerophytic plants and red beds in the subtropical desert biome in spite of its location at the equator. The presence of this subtropical biome at the equator can be explained by the perfect symmetry of the continental surfaces at the equator (Parrish 1995). The correlations are excellent between the northern Peri-Tethyan and Tethyan domains. The presence of two opposite climates at the equator during the Westphalian and the Early Permian makes the correlations easier.

In the southern Peri-Tethyan domain (Fig. 1), North Africa was located at 10°S during the Westphalian and at the equator during the Early Permian. Libya, Egypt and Saudi Arabia were located at the 25°S during the Westphalian and 20°S during the Early Permian; Oman and the Salt Range were located at 50°S during the Westphalian and at 40°S during the Early Permian. In North Africa, the Westphalian and the Stephanian present hygrophytic plants and coal in the everwet biome, the Autunian xerophytic plants growing on the slopes of basins and red beds in the summerwet biome, the Saxonian xerophytic plants and red beds in the subtropical desert biome in spite of its location at the equator and for the same reason as the Tethyan domain. In Libya, Egypt and Saudi Arabia, the plants were xerophytic during the Westphalian and the Early Permian. In Oman and the Salt Range as in all Gondwanaland, the plants lived in a cool to temperate climate. These different

latitudinal locations make the correlations difficult between Europe and Gondwanaland.
During the Late Carboniferous and Early Permian, three realms are defined (Ziegler 1990): the tropical Cathaysian (biome 1) in China and Euramerican-Atlantic in Europe and North America (biome 1 during Carboniferous and biomes 2 and 3 during Permian) realm, the North temperate Angaran realm (biomes 4 to 8) in Siberia and the southern temperate Gondwanan realm (biomes 5 to 10) in Gondwana. Biome 1, represented by tropical rainforests populated by arborescent hygrophytic flora, was known in China during the Carboniferous and Permian and in Europe and North America during the Late Carboniferous. Biome 2 was represented by *Callipteris* and primitive conifers (*Walchia*) during the Early Permian in Europe, North Africa and North America. Biome 6 was represented by *Glossopteris* and Biome 8 by *Gangamopteris* in Gondwana.

CORRELATIONS FOUND ON THE SEQUENCE STRATIGRAPHY

A sequence stratigraphy of the Carboniferous and Permian was built by Ross & Ross (1987, 1994, 1995). Second order, third order (Figs 5-7), fourth order and high frequency sequences were defined in eastern Europe in Moscow Basin (Briand *et al.* 1998), the Donets Basin (Izart *et al.* 1996 and 1998) and the Central Ural Basin (Izart *et al.* 1998), and in the western Europe in paralic and limnic basins (Izart & Vachard 1994), in the foreland basin of Asturias and in the rift basin of the Carnic Alps (Samankassou 1997; Vai & Venturini 1997; Krainer & Davydov, this volume), in the intracontinental basins or the marine platform of North Africa (Izart 1991).
For the Late Carboniferous, the same number of third order and second order sequences was found in the Moscow and Donets Basins and a different number in western Europe. In the Moscow and Donets Basins, the Moscovian, Kasimovian and Gzhelian-Orenburgian deposits each form a second order sequence, the Moscovian is subdivided into four third order sequences, the Kasimovian into three or four sequences and the Gzhelian-Orenburgian into four or five sequences. In western Europe, the Westphalian presents four third order sequences, the Stephanian two, the Autunian one, the Saxonian one. The number of sequences is different from Ross & Ross (1987), who used fourth order sequences. In eastern Europe, they resulted from the eustacy that produced synchronous sequences and tectonics. In western Europe, the sequences are tectonically controlled and heterochronous with eastern Europe.
For the Late Carboniferous, the fourth order sequences (FOS, 400 000 y.) and high frequency sequences (HFS, 40 000 y. to 250 000 y.) are variable everywhere, as shown by Izart & Vachard (1994) and these results: for Moscovian, eleven FOS and forty HFS in Moscow and eighteen FOS and one hundred HFS in Donets; for Kasimovian, eight FOS and twenty HFS in Moscow, seven FOS and twenty-six HFS in Donets; for Gzhelian-Orenburgian, nine FOS and twenty-four HFS in Moscow, sixteen FOS and fifty-two HFS in Donets; for Westphalian, ten FOS in western Europe and for Westphalian C, four FOS and sixteen HFS in England; four FOS and forty HFS in North France and Germany. The number of FOS is different from Ross & Ross (1987) and the number is variable everywhere. In the Moscow Basin, eustacy prevails certainly over tectonics and in the Donets and western Europe Basins, tectonics prevail over eustacy. The average duration of HFS in the Moscow and western Europe Basins is near the periodicity of eccentricity (100 000 y.) and in the Donets Basin near the periodicity of obliquity (40 000 y.). However, a better accuracy of time by radiochronology is needed to calibrate these sequences.
The Early Permian deposits in Central Ural form two second order sequences, one during Asselian and one during the Sakmarian and Artinskian, five third order sequences for the Asselian, three for the Sakmarian, two composite for Artinskian and one composite for the Kungurian. The Early Permian deposits in the Donets Basin form one second order sequence during the Asselian and the Sakmarian, three third order sequences during the Asselian and one during the

Sakmarian. The number of sequences is weakly different from Ross & Ross (1987, 1994, 1995): five for Asselian, four or five for the Sakmarian, three or four for the Artinskian and one composite or two for the Kungurian. These sequences are controlled by eustacy and tectonics in the Ural foreland Basin and the Donets Basin.

For the Early Permian, the fourth order sequences (FOS) and high frequency sequences (HFS) are variable everywhere: for the Asselian, eleven FOS and eighteen HFS in Donets and a number superior to twenty-four HFS in Central Urals; for Sakmarian, ninety-two HFS in Central Urals; for the early Artinskian (Bursevkian-Irginian), seventeen HFS in Central Urals. These sequences are controlled by eustacy and tectonics. The average duration of HFS is near the periodicity of eccentricity (100 000 y.).

The tectonic control was important in the Asturias and the eustatic control rules over in the Carnic Alps. The sequences are heterochronous in the Asturias and synchronous with eastern Europe in the Carnic Alps. The tectonics prevails in the continental basins of Morocco, the eustacy in the marine basins in Morocco, Algeria, Tunisia, Libya and Egypt. These sequences of the southern Peri-Tethyan domain are heterochronous in the intracontinental basins and synchronous with eastern Europe in the marine basins. The beginning of the sedimentation in the continental stages of the Late Carboniferous and Early Permian are heterochronous according to the tectonic phases affecting each basin, even though it is synchronous in the marine stages that are under the control of the eustacy.

CONCLUSION

Stratigraphic correlations (Fig. 8) are proposed between the marine and continental facies in the northern Peri-Tethyan, Tethyan and southern Peri-Tethyan domains. The base of the Moscovian would be located between the late part of the Westphalian B and the base of the Westphalian C in the northern Peri-Tethyan domain, between the bases of the Westphalian A and C in the Tethyan domain, at the base of the Westphalian C in the southern Peri-Tethyan domain. The Moscovian would be equivalent to the Westphalian C and D in the northern and southern Peri-Tethyan domains and to an imprecise time interval (Westphalian A to Cantabrian *p.p.*) in the Tethyan domain. The Kasimovian would correspond to the early Stephanian in the northern Peri-Tethyan domain, to the Cantabrian *p.p.* and the early Stephanian in the Tethyan domain. The equivalence between the Kasimovian and the early Stephanian is not established in the southern Peri-Tethyan domain. The Gzhelian would be equivalent to the late Stephanian and the Orenburgian to the lower part of the Autunian in the northern Peri-Tethyan domain with an uncertainty, because we can choose either the appearance of xerophytic plants, or the acme for the definition of the base of the Autunian. In the Carnic Alps, the Gzhelian would be equivalent to the late Stephanian. The equivalence between the Gzhelian and the late Stephanian is not established in the southern Peri-Tethyan domain. The marine Early Permian would be equivalent to the continental Early Permian in all the domains, the Autunian and the Saxonian remain difficult to separate. A latitudinal good correlation is observed on the continents except near Gondwanaland. A good correlation linked with the eustacy is observed in the marine domain and a heterochrony in the beginning of the sedimentation linked with the tectonics is reported in the continental domain.

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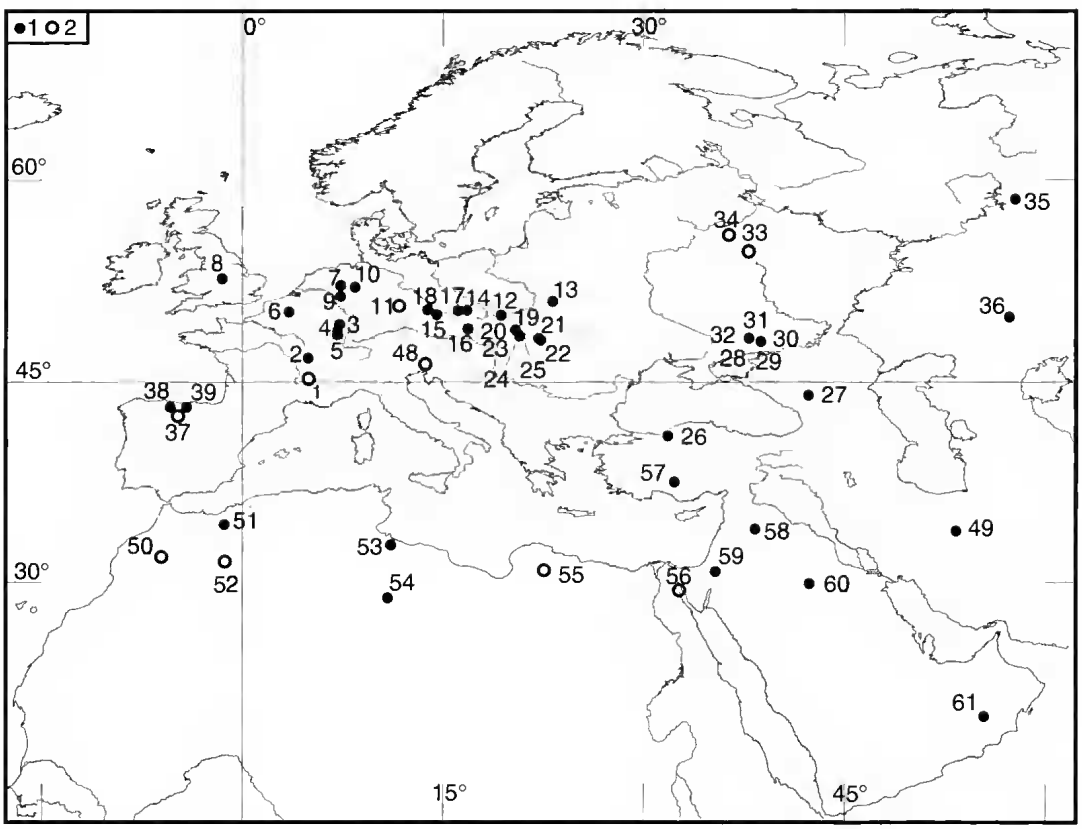
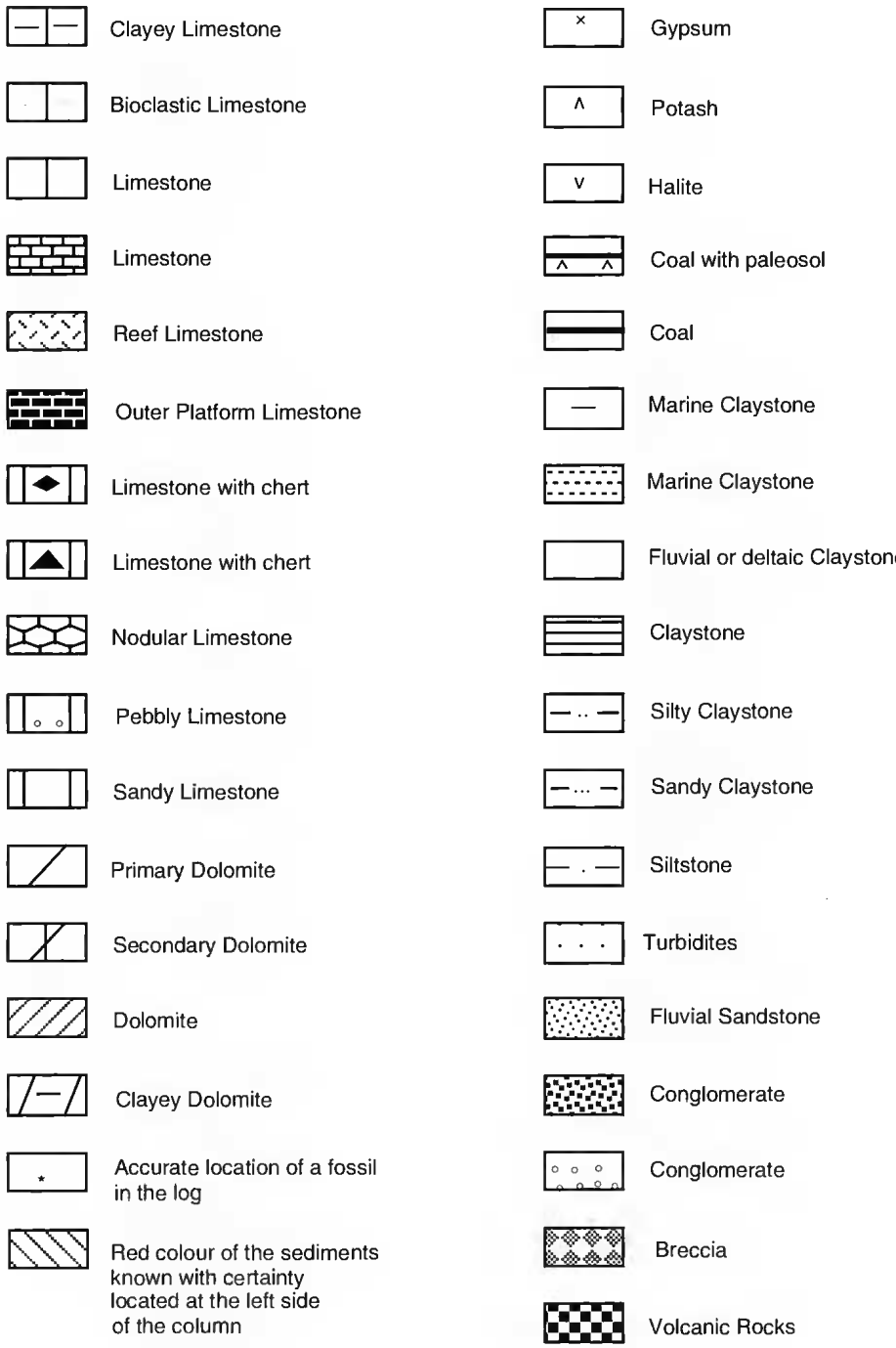
APPENDIX 1

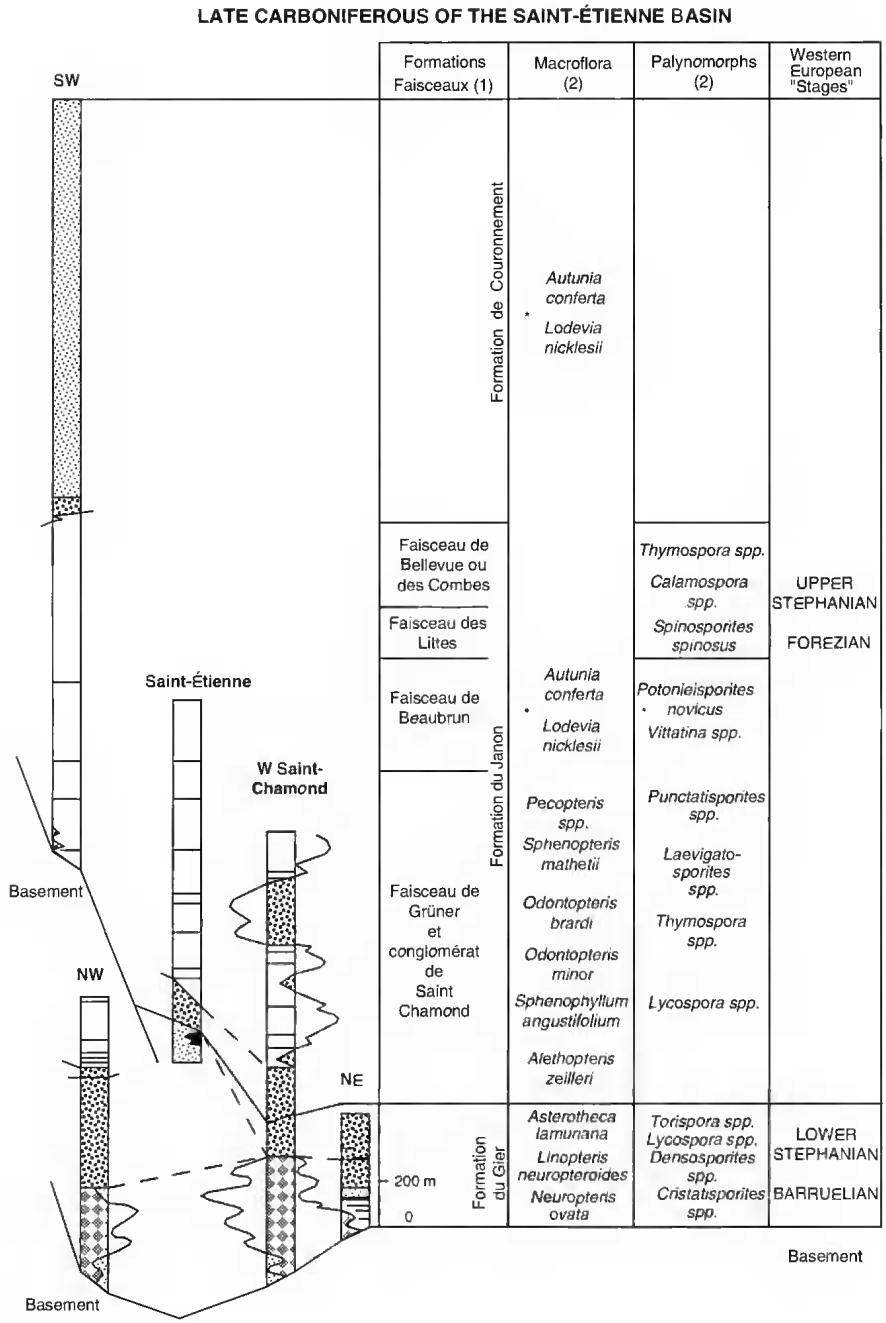
Late carboniferous and Early Permian logs and tables.
Northern Peri-Tethyan Basins (logs 1-36); Tethyan Basins (logs 37-49);
Southern Peri-Tethyan Basins (logs 50-62).



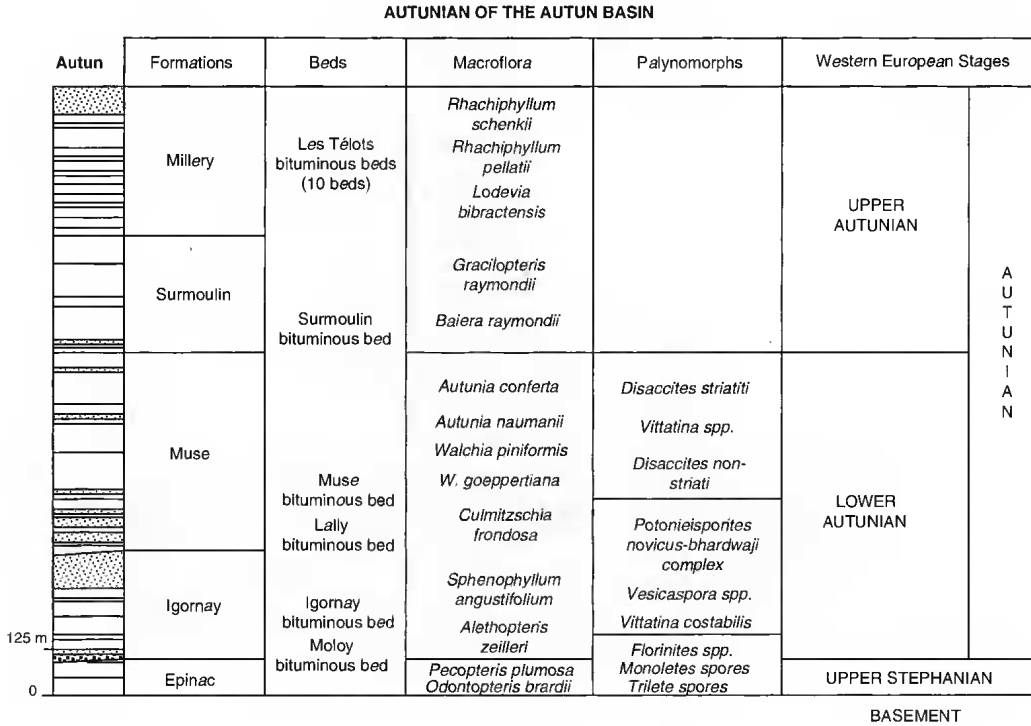
MAP. — Location of the logs or sections presented in the appendix 1. Map realized by the Peri-Tethys cartographic team. Pakistan table (62) is not located on the map. **1**, log or section; **2**, synthetic log or section.

LEGEND

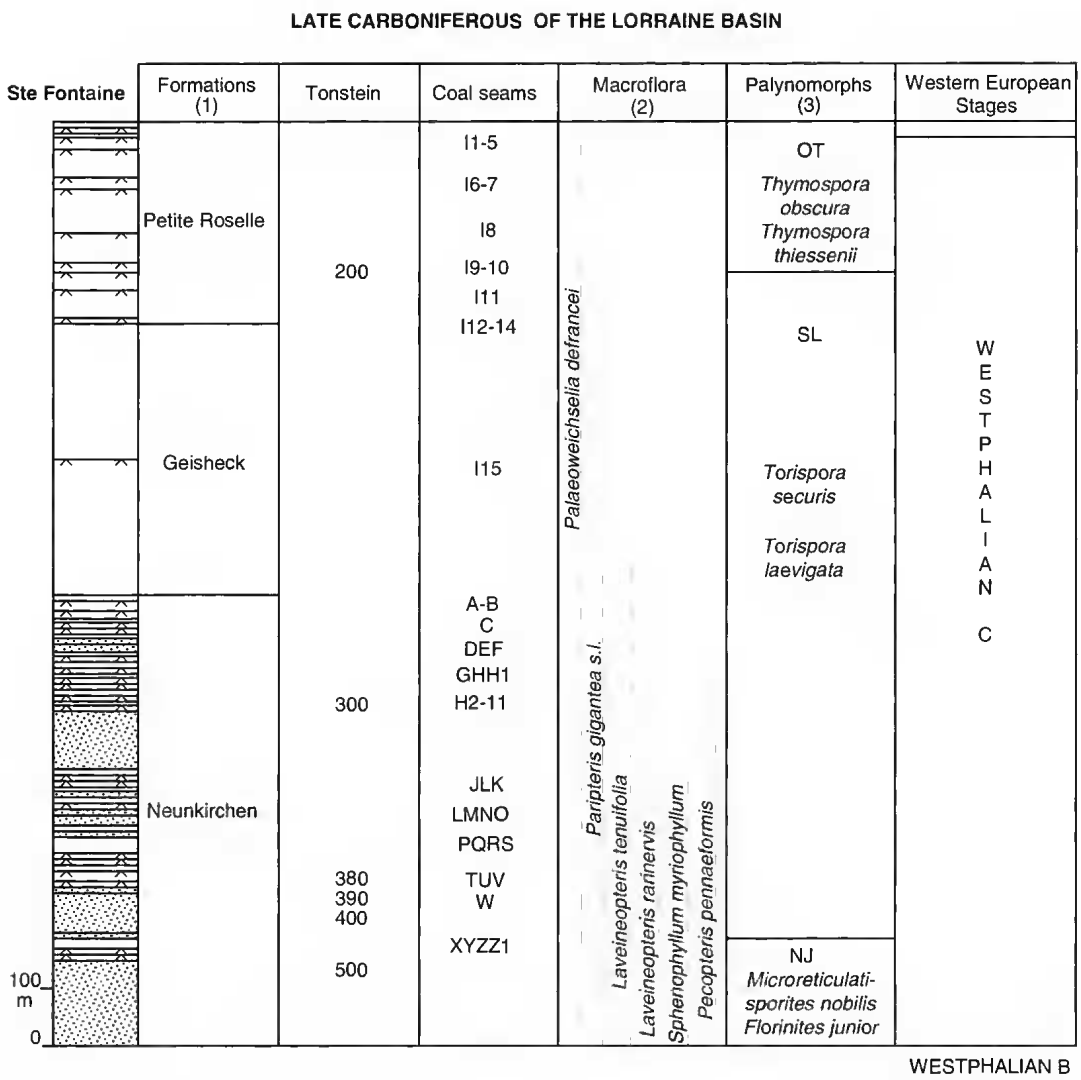

Clayey Limestone
Bioclastic Limestone
Limestone
Limestone
Reef Limestone
Outer Platform Limestone
Limestone with chert
Limestone with chert
Nodular Limestone
Pebbly Limestone
Sandy Limestone
Primary Dolomite
Secondary Dolomite
Dolomite
Clayey Dolomite
Accurate location of a fossil in the log
Red colour of the sediments known with certainty located at the left side of the column
Gypsum
Potash
Halite
Coal with paleosol
Coal
Marine Claystone
Marine Claystone
Fluvial or deltaic Claystone
Claystone
Silty Claystone
Sandy Claystone
Siltstone
Turbidites
Fluvial Sandstone
Conglomerate
Conglomerate
Breccia
Volcanic Rocks



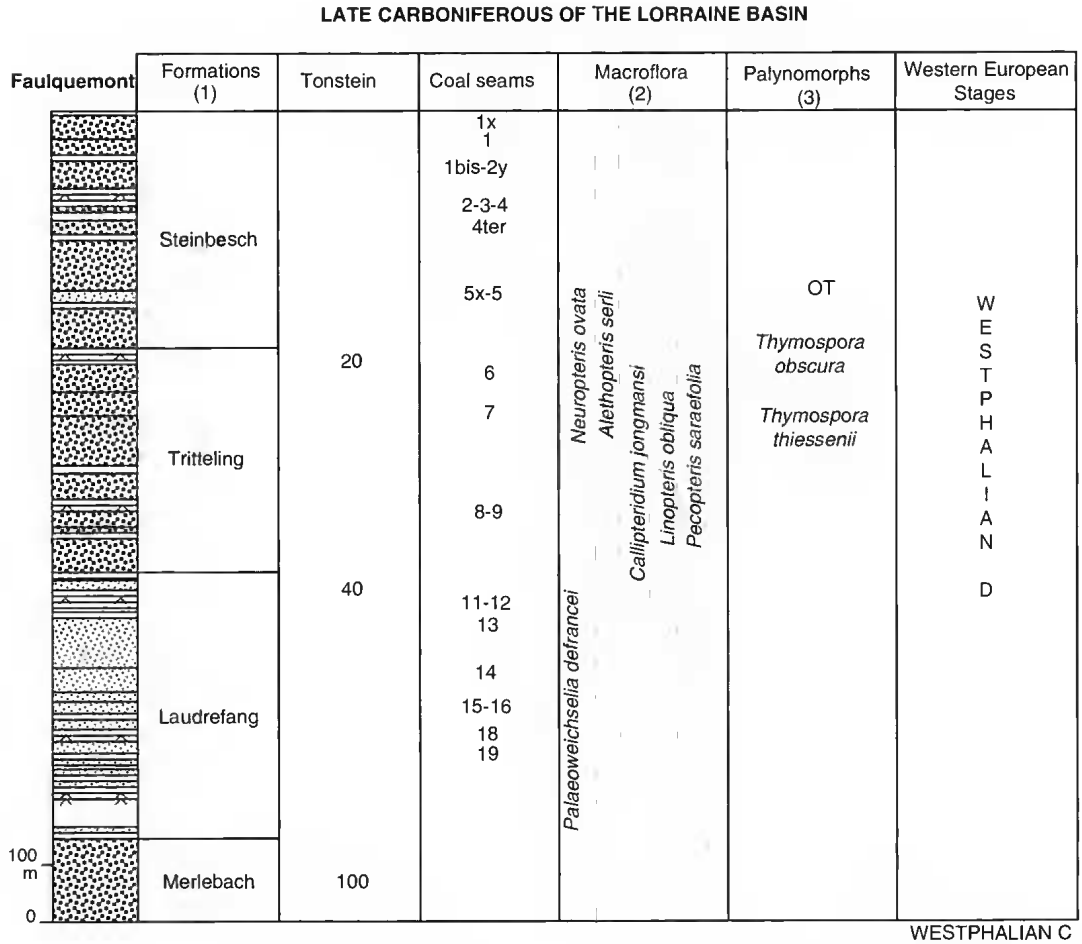
Log. 1. — Late Carboniferous of the Saint-Étienne Basin, coordinated by Mercier and Broutin. **1**, Mercier (this paper); **2**, Broutin (this paper). Saint-Étienne, France, 4°24'E - 45°27'N; Firminy, ex-SW, 4°15'E - 45°24'N; La Fouillouse, ex-NW, 4°19'E - 45°30'N; W Saint-Chamond, 4°30'E - 45°29'N; Rive-de-Gier, ex-NE, 4°37'E - 45°31'N.



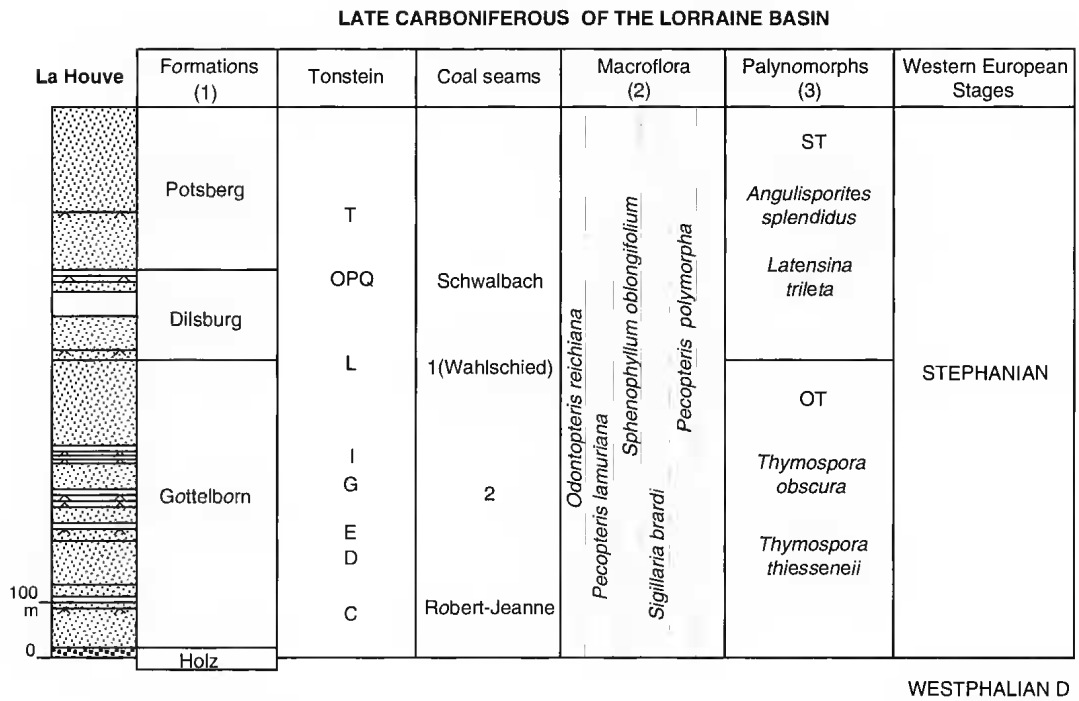
LOG. 2. — Autunian of the Autun Basin, coordinated by Broutin, after Broutin *et al.* (1996). Autun, France, 4°30'E - 47°N.



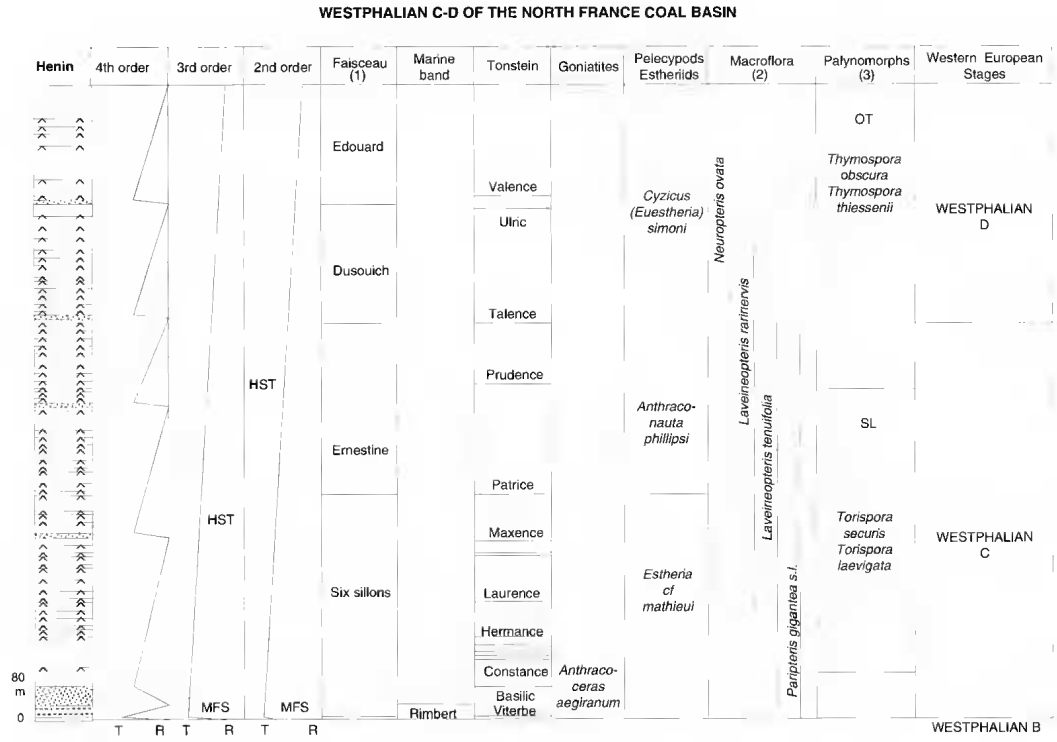
Log. 3. — Late Carboniferous of the Lorraine Basin, coordinated by Donsimoni, Laveine and Coquel, Sainte-Fontaine, 6°48'E - 49°30'N. **1**, Donsimoni (this paper); **2**, Laveine (this paper); **3**, Coquel (this paper).



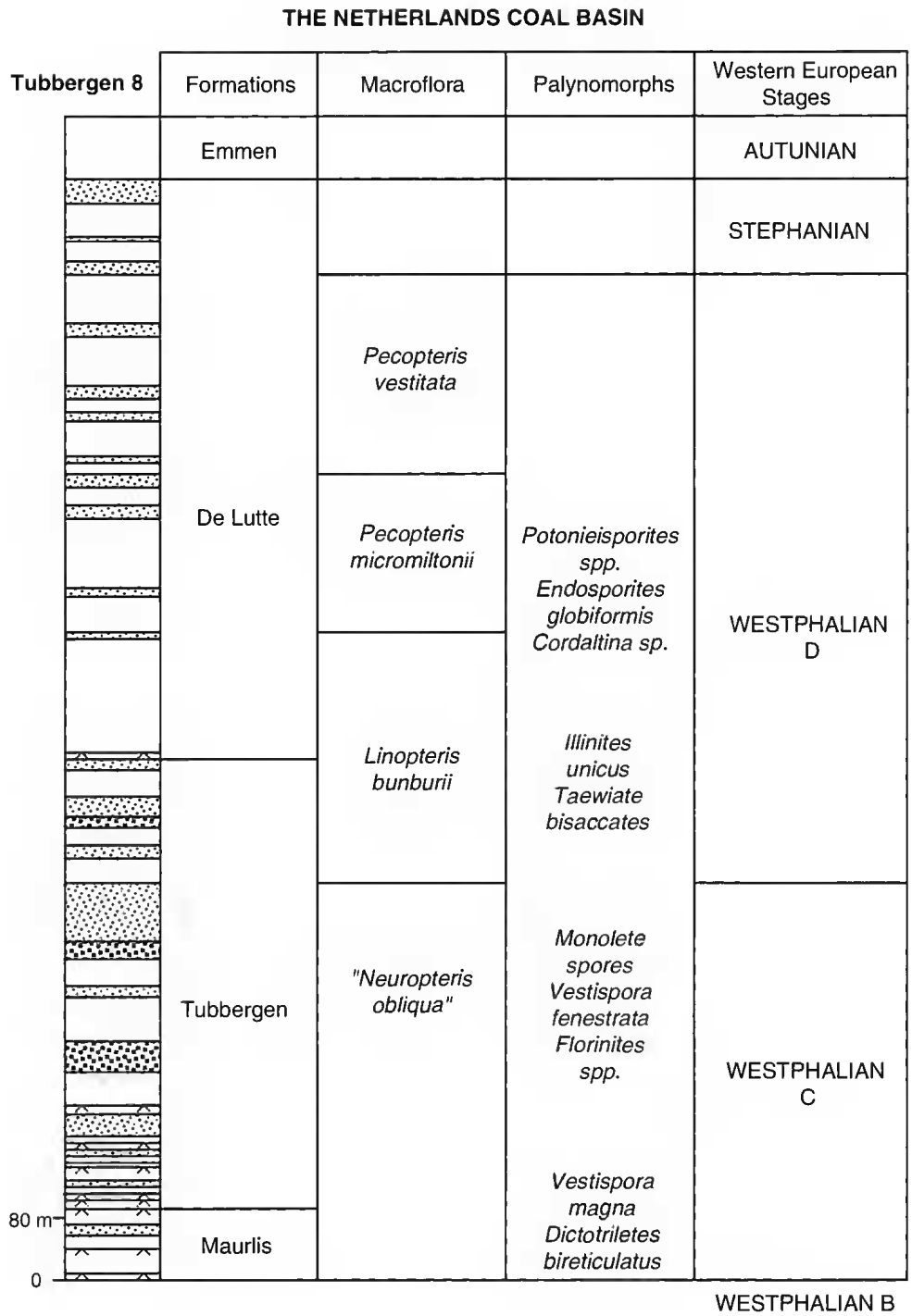
LOG. 4. — Late Carboniferous of the Lorraine Basin, coordinated by Donsimoni, Laveine and Coquel, Faulquemont, 6°38'E - 49°02'E. **1**, Donsimoni (this paper); **2**, Laveine (this paper); **3**, Coquel (this paper).



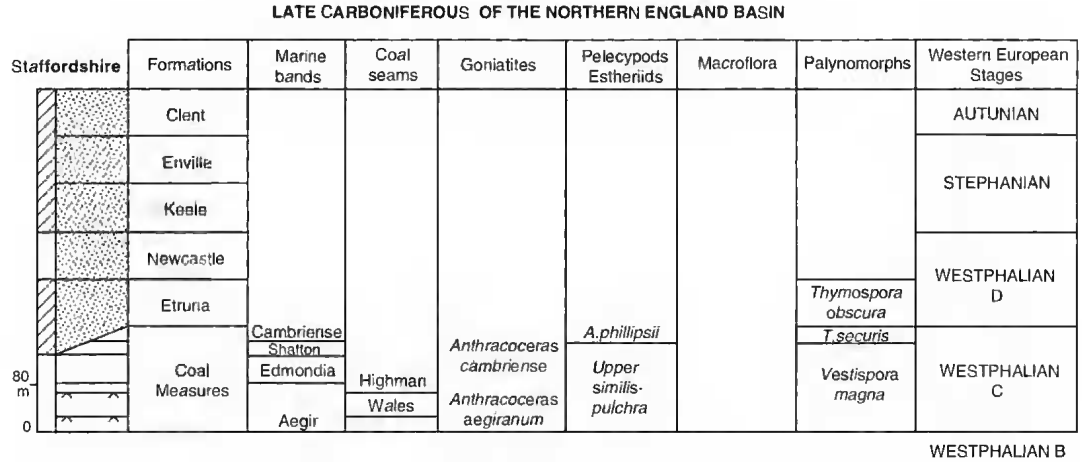
LOG. 5. — Late Carboniferous of the Lorraine Basin, coordinated by Donsimoni, Laveine and Coquel, La Houve, 6°38'E - 48°45'N. **1**, Donsimoni (this paper); **2**, Laveine (this paper); **3**, Coquel (this paper).



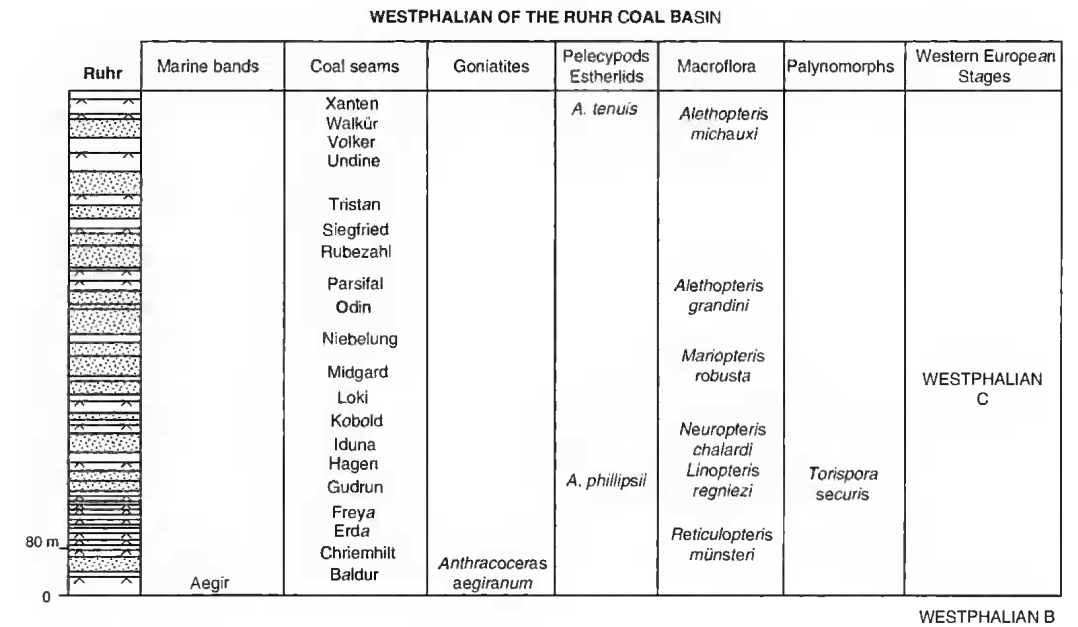
LOG. 6. — Westphalian C and D of the North France Basin, coordinated by Izart, Laveine and Coquel. **1**, Izart after Bouroz *et al.* (1964); **2**, Laveine (this paper); **3**, Coquel (this paper). Hénin, North France, 3°E - 50°30'N.



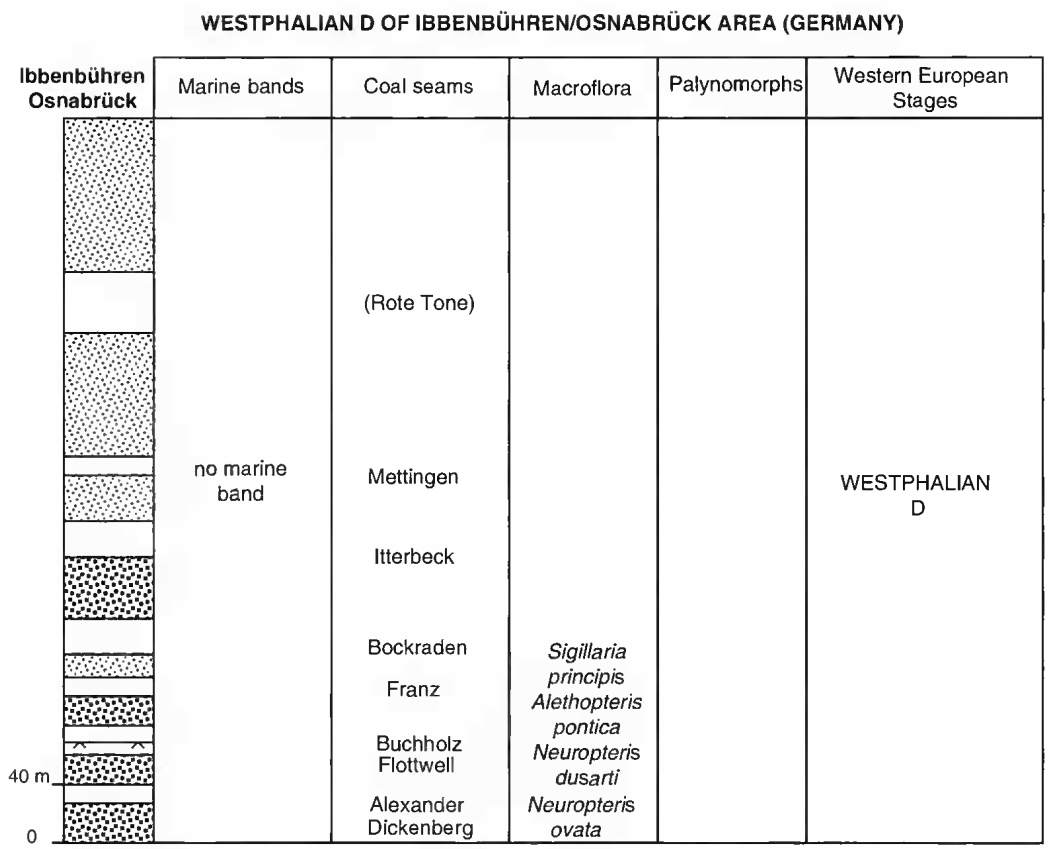
Log. 7. — The Netherlands coal Basin, coordinated by Gelük, after Gelük (1997). Tubbergen-8, 6°53'E - 52°26'N.



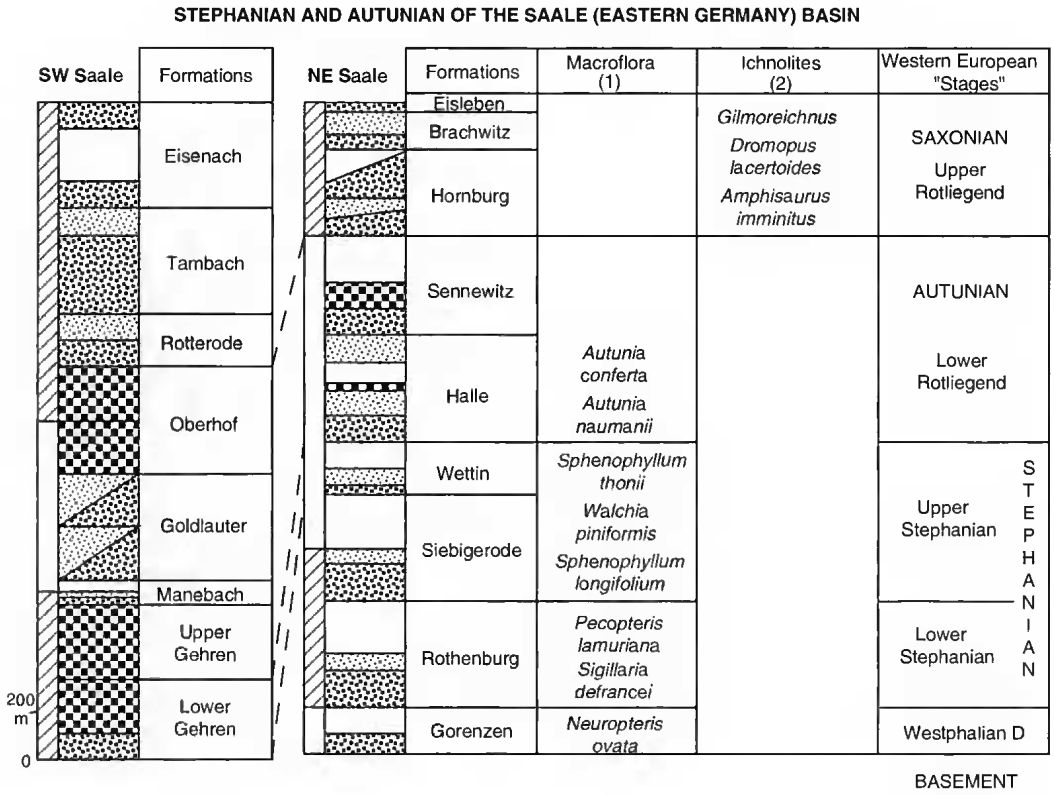
Log. 8 — Late Carboniferous of the Northern England Basin, coordinated by Izart, Izart (this paper) after Ramsbottom *et al.* (1978). Stafford, North England, 2°W - 52°50'N.



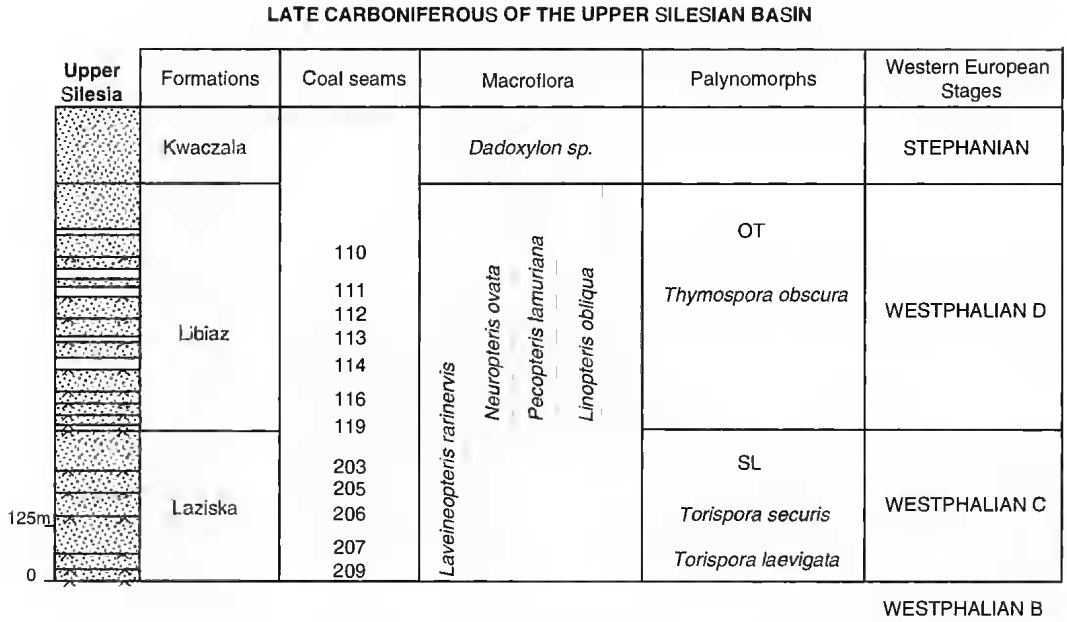
Log. 9. — Germany Basins. Westphalian of the Ruhr coal Basin, coordinated by Süss after Fiebig (1969) and Josten (1991). Lippermulde 1, Ruhr, Germany, 6°52'E - 51°37'N.



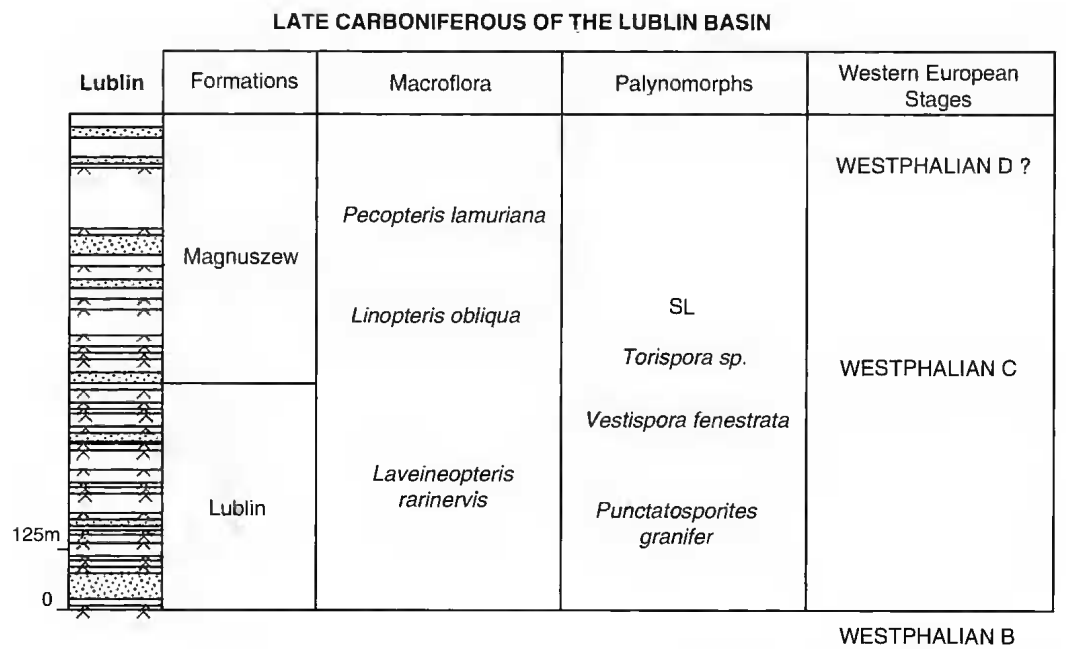
Log. 10. — Germany Basins. Westphalian of the Ibbenbühren/Osnabrück area coordinated by Süss, after Josten (1991). Ibbenbühren, Osnabrück, 8°E - 52°20'N.



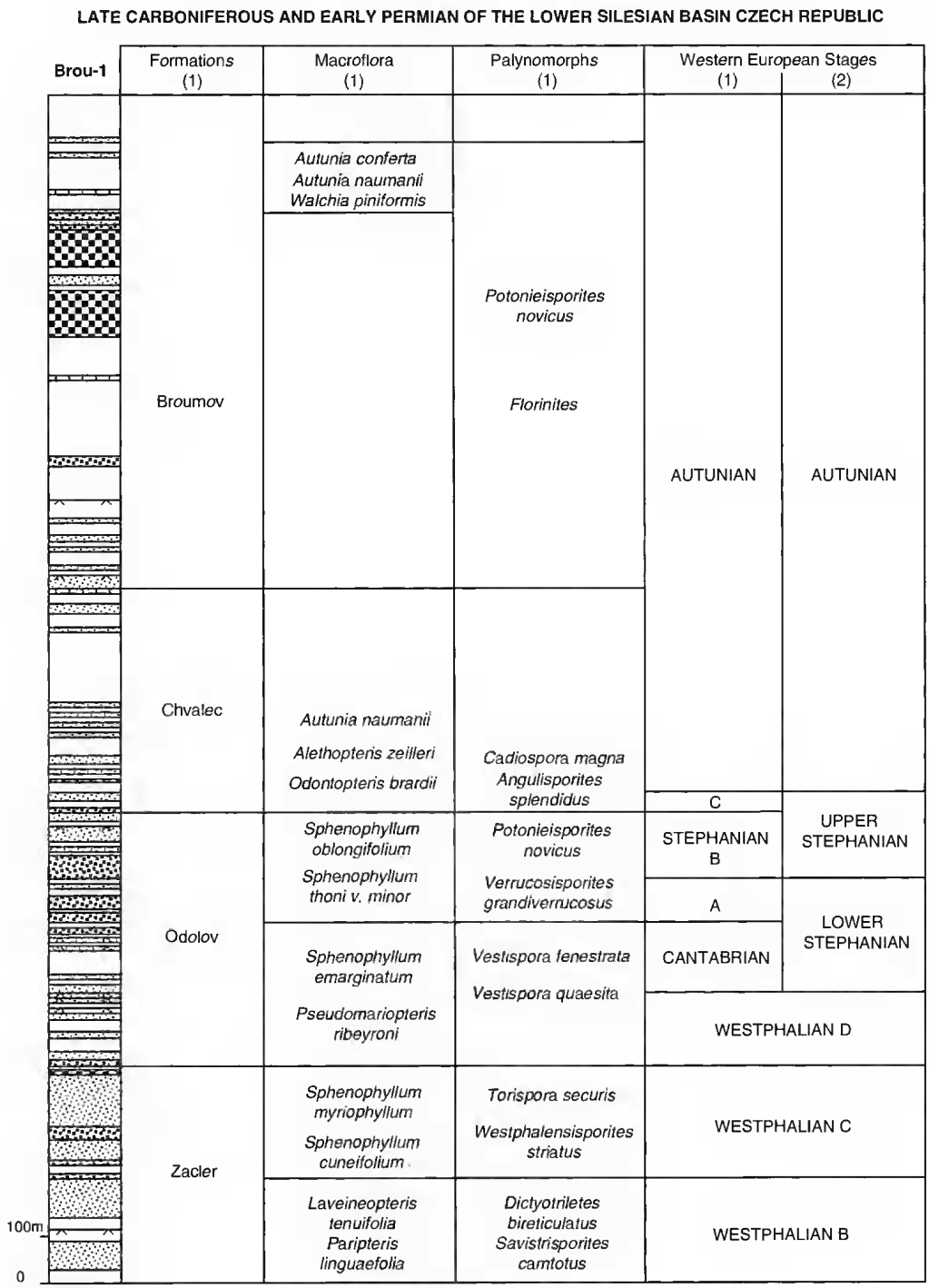
LOG. 11. — Germany Basins. Stephanian and Autunian of the Saale (eastern Germany) Basin, coordinated by Izart, Izart (this paper) after Schneider & Rossler (in press); **1**, Broutin (this paper); **2**, Lützner (1987). Halle, NE Saale, 12°E - 51°30'N; Tambach, SW Saale, 10°36'E - 50°48'N.



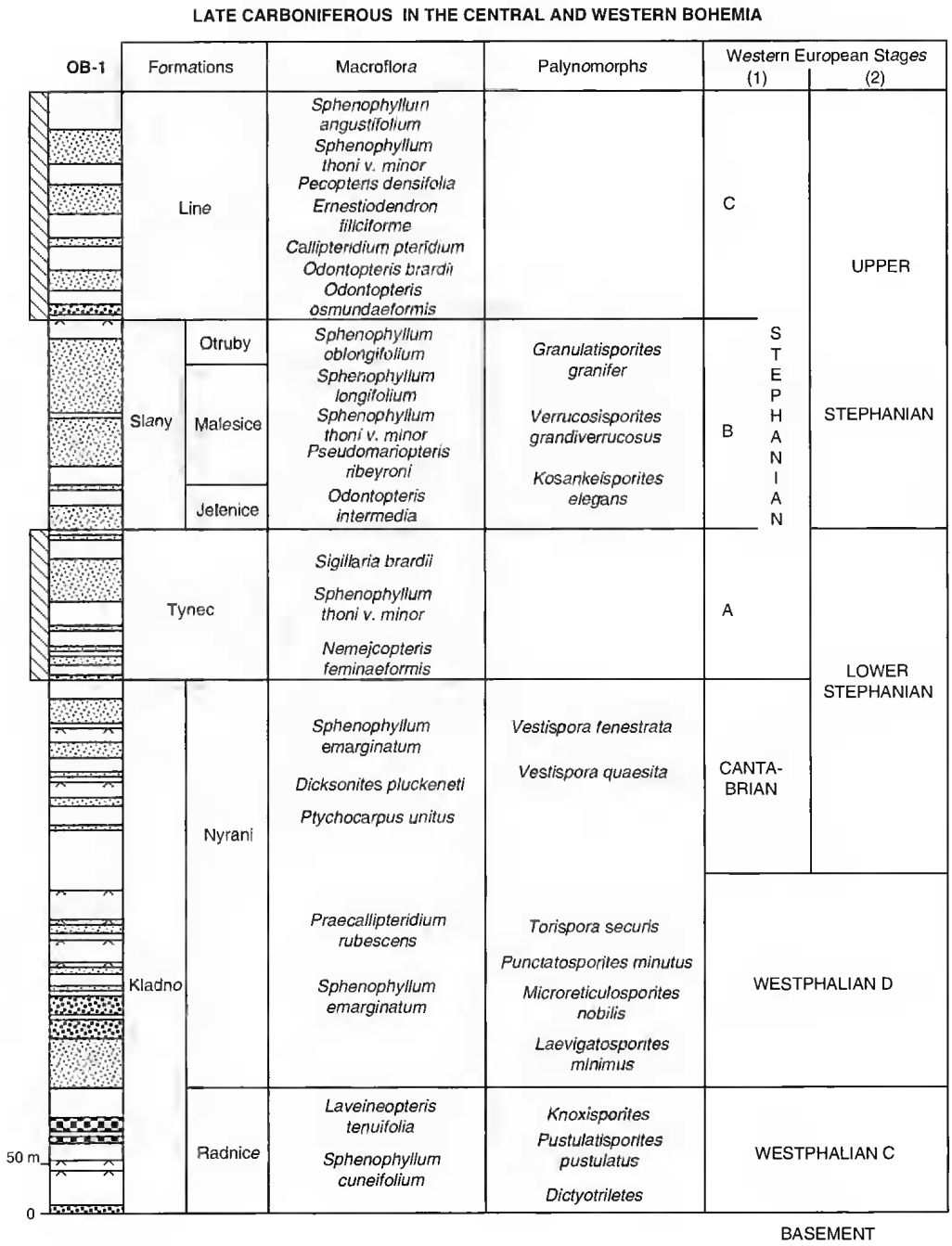
LOG. 12. — Poland Basins, coordinated by Izart, Late Carboniferous of the upper Silesian Basin, Izart (this paper) after Zdanowski & Zakowa (1995). Katowice, Poland, 19°E - 50°15'N.



LOG. 13. — Poland Basins, coordinated by Izart. Late Carboniferous of the Lublin Basin, Izart (this paper) after Zdanowski & Zakowa (1995). Lublin, Poland, 22°45'E - 51°15'N.

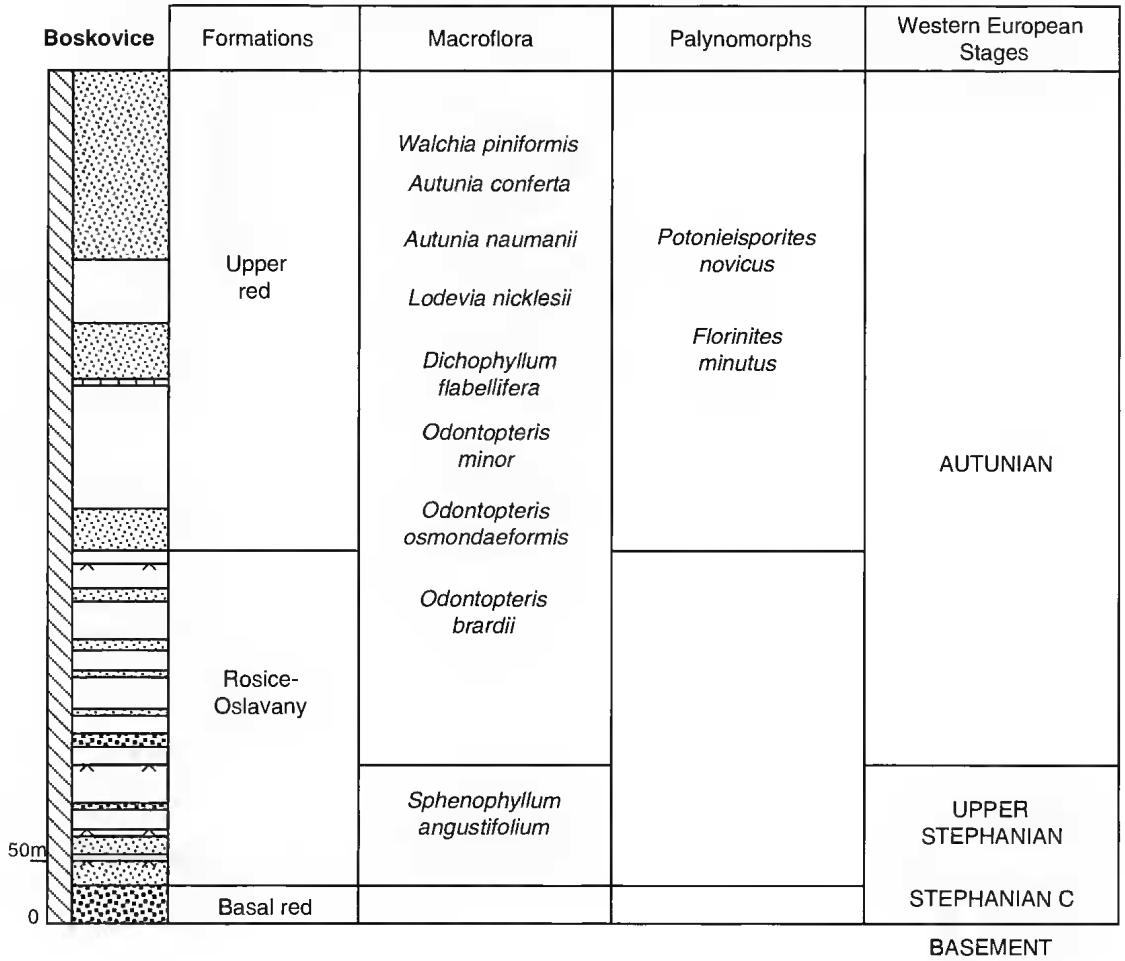


LOG. 14. — Czech Republic Basins, coordinated by Oplustil, Pesek, Martinek, Simunek & Drabkova. Late Carboniferous and Early Permian of the lower Silesian Basin. **1**, Oplutil *et al.* (this volume); **2**, this paper. Broumov, Czech Republic, 16°21'E - 50°35'N.

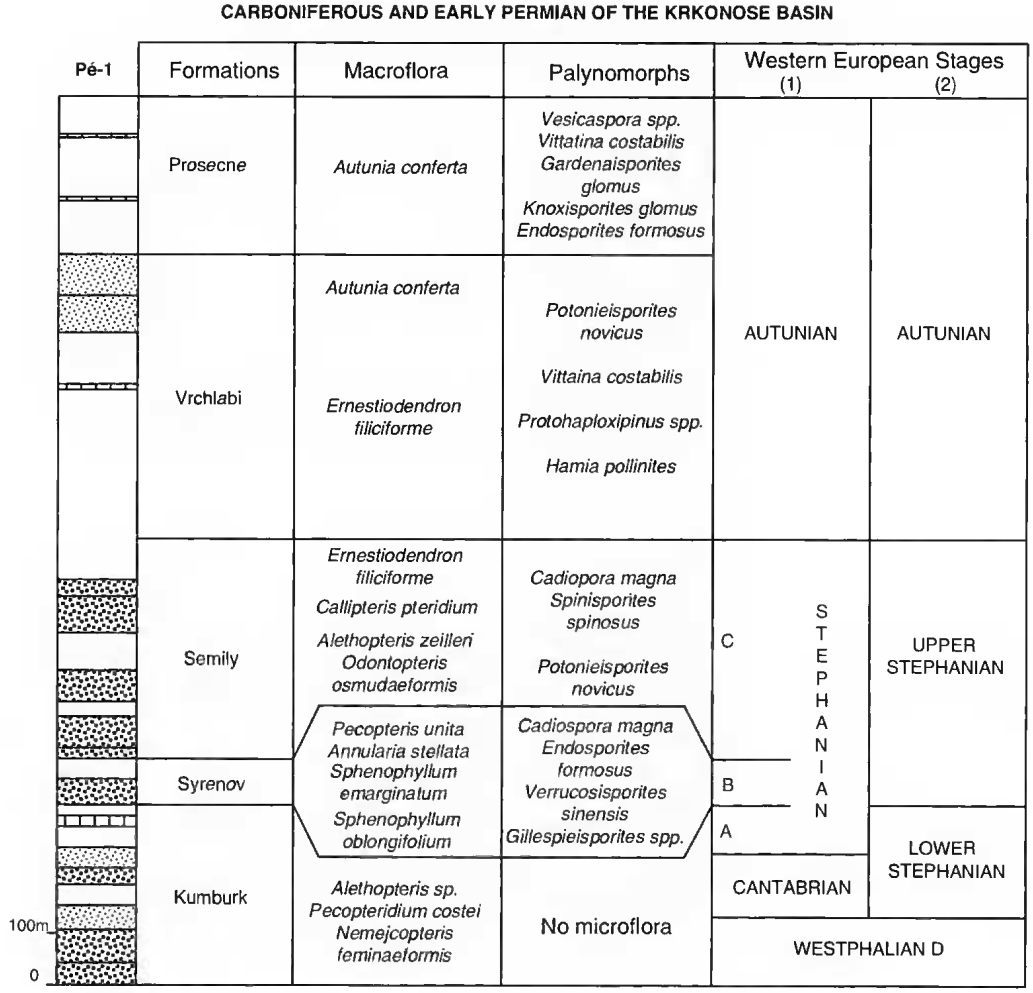


Log. 15. — Czech Republic Basins, coordinated by Oplustil, Pesek, Martinek, Simunek & Drabkova. Late Carboniferous in the central and western Bohemian. **1**, Oplustil *et al.* (this volume); **2**, this paper. Otruby, Czech Republic, 14°06'E - 50°15'N.

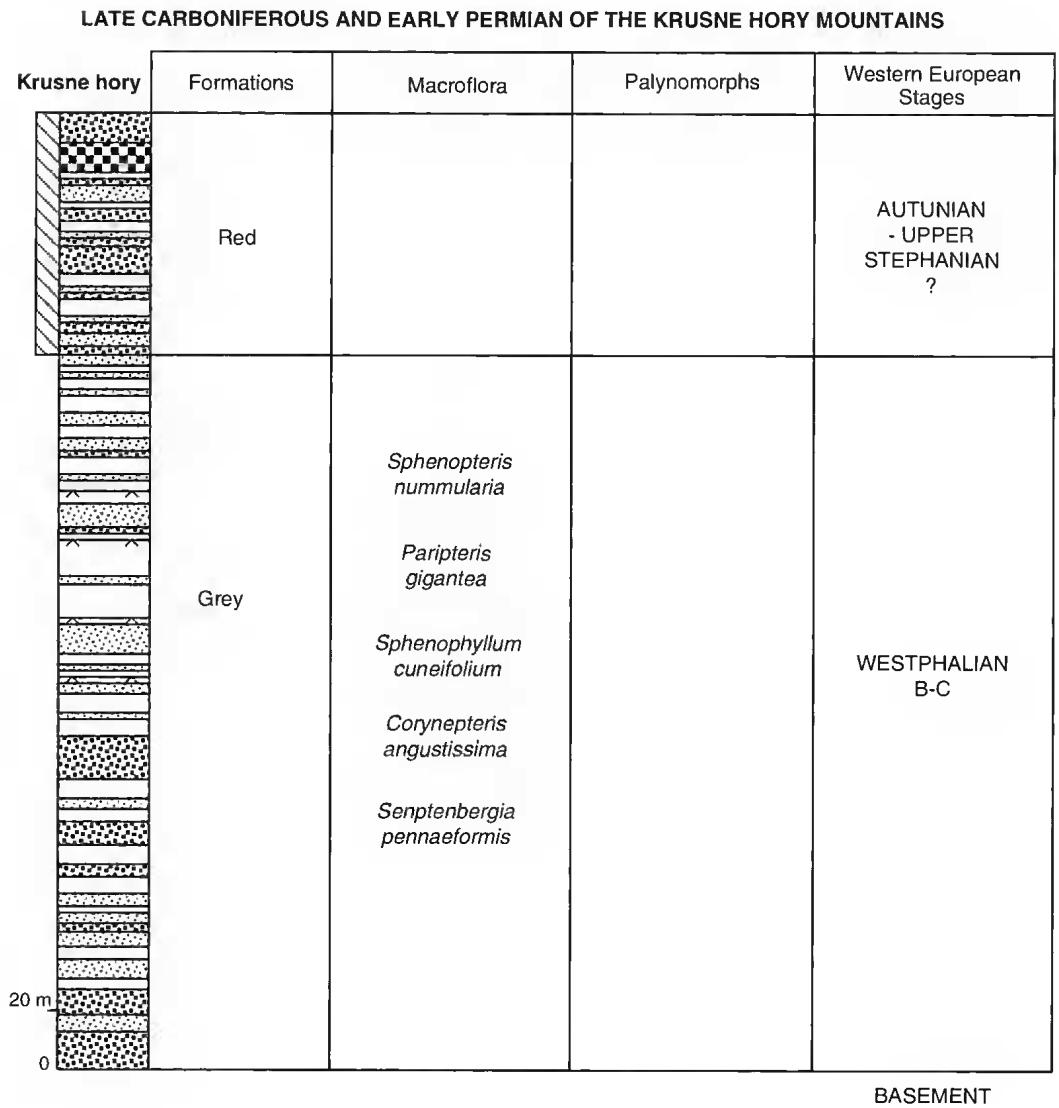
LATE CARBONIFEROUS AND EARLY PERMIAN OF THE BOSKOVICE FURROW



LOG. 16. — Czech Republic Basins, coordinated by Oplustil, Pesek, Martinek, Simunek & Drabkova. Late Carboniferous and Early Permian of the Boskovice Furrow, after Oplustil *et al.* (this volume). Boskowice, Czech Republic, 16°25'E - 49°10'N.

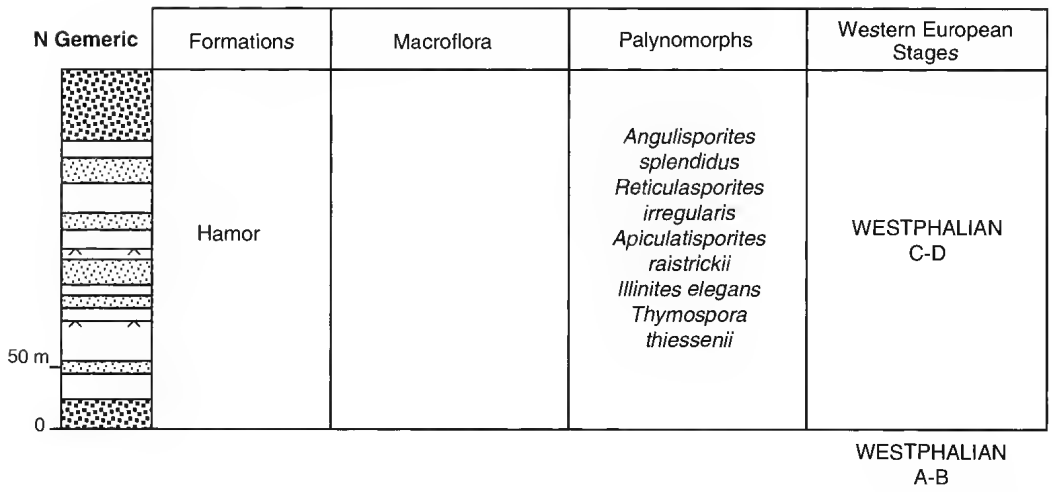


LOG. 17. — Czech Republic Basins, coordinated by Oplustil, Pesek, Martinek, Simunek & Drabkova. Carboniferous and Early Permian of the Krkonose Basin. **1**, Martinek *et al.* this volume; **2**, this paper. Prosecne, Czech Republic, 15°41'E - 50°34'N.

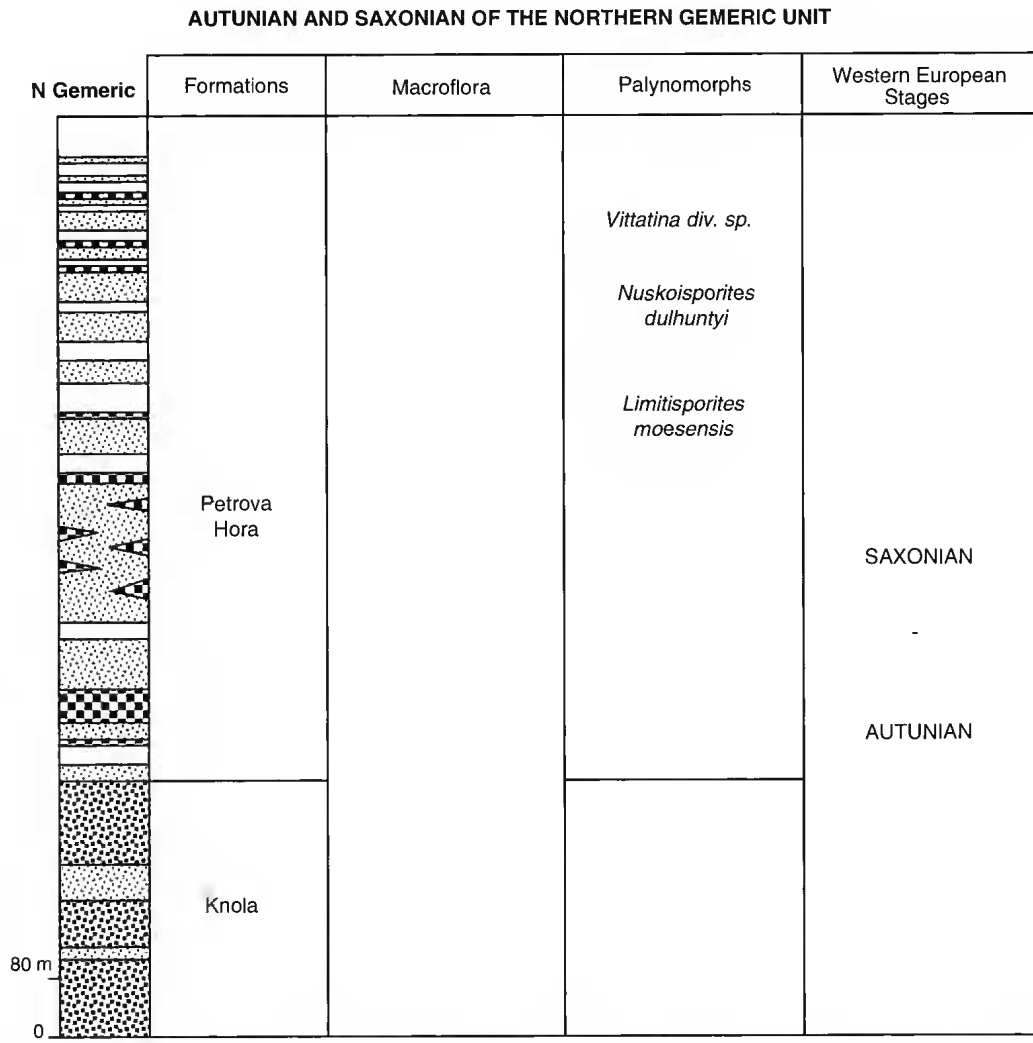


Log. 18. — Czech Republic Basins, coordinated by Oplustil, Pesek, Martinek, Simunek & Drabkova. Late Carboniferous and Early Permian of the Krusne hory Mountains, after Oplustil *et al.* (this volume). Krusne Hory, Czech Republic, 13°24'E - 50°37'N.

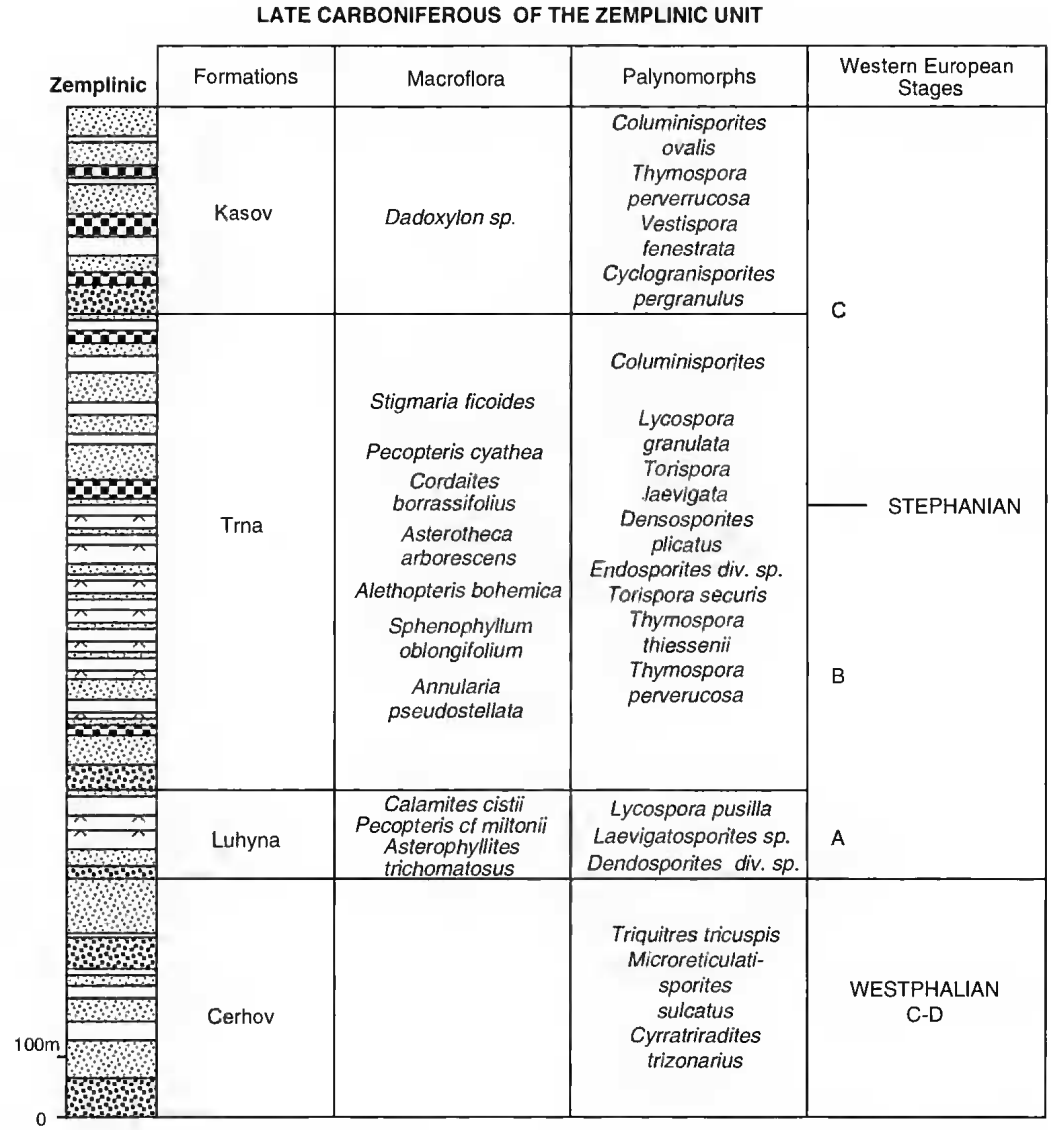
MOSCOVIAN OF THE NORTHERN GEMERIC UNIT



Log. 19. — Slovak Republic Basins, coordinated by Vozarova. Moscovian of the northern Gemeric unit (Slovak Republic), after Vozarova (this paper). Northern Gemeric, Slovak Republic, 20°30'E - 48°55'N.

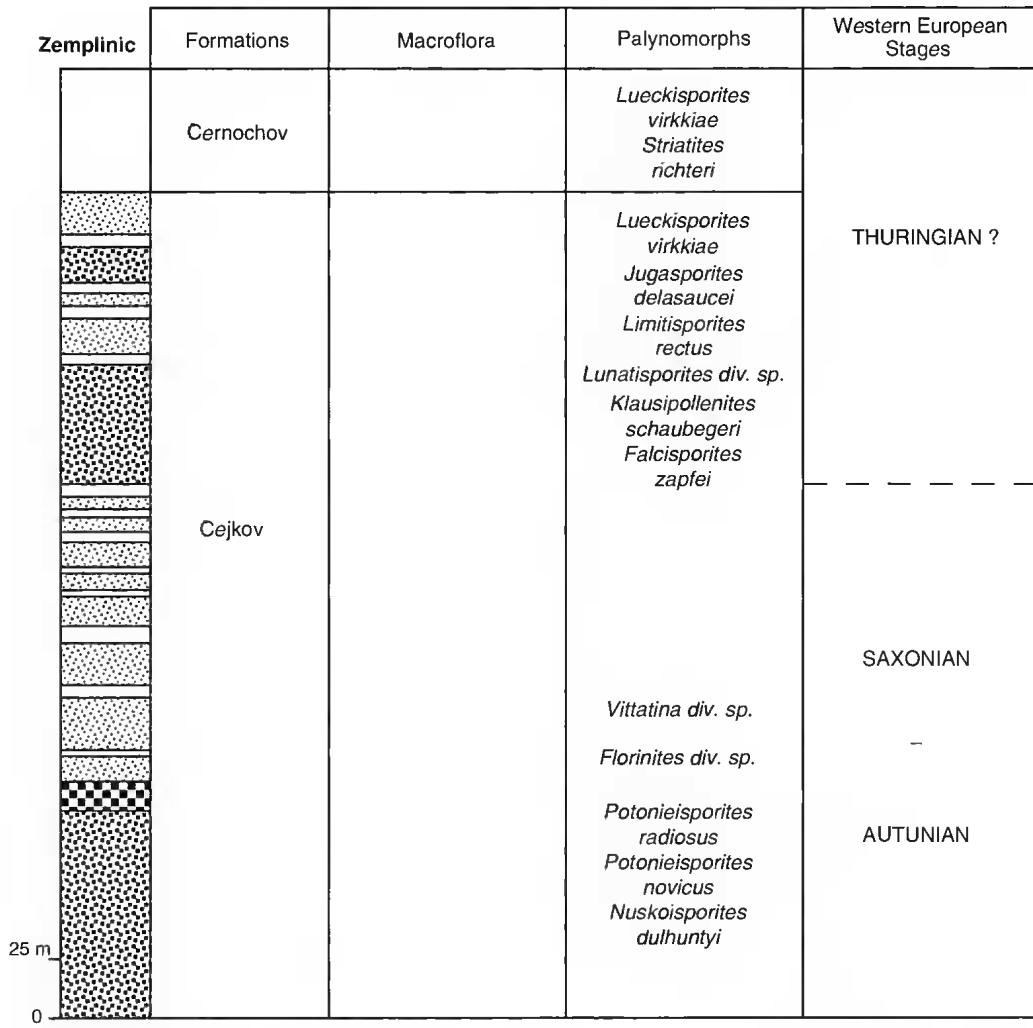


Log. 20. — Slovak Republic Basins, coordinated by Vozarova. Autunian and Saxonian of the northern Gemeric unit (Slovak Republic), after Vozarova (this paper). North Gemeric, Slovak Republic, 20°30'E - 48°55'N.

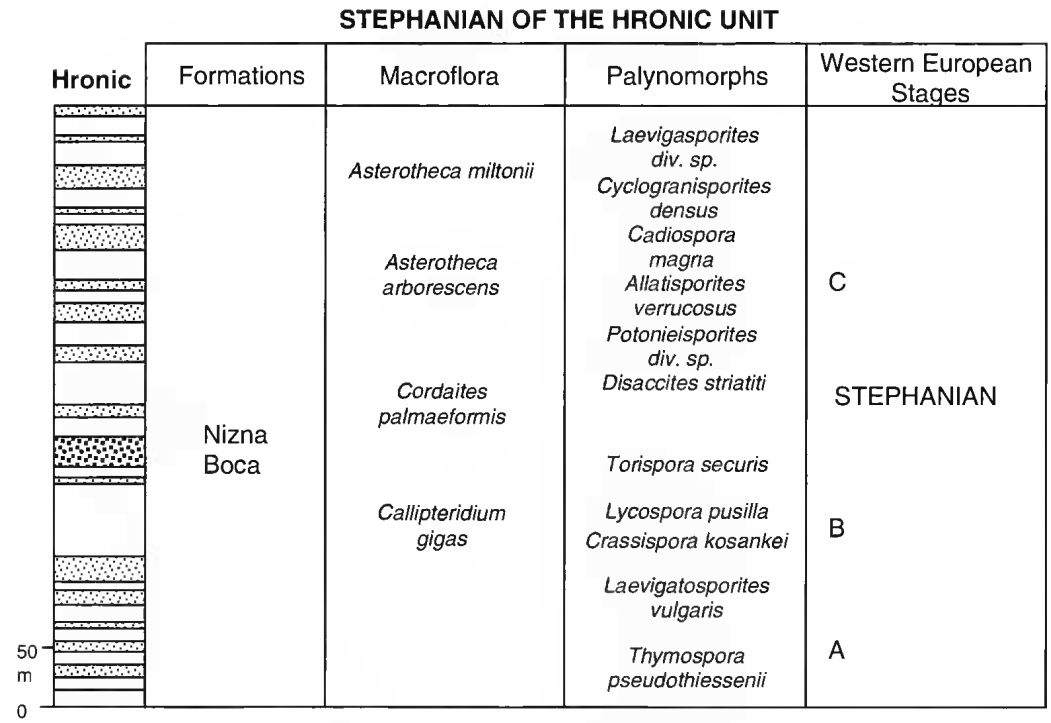


Log. 21. — Slovak Republic Basins, coordinated by Vozarova. Late Carboniferous of the Zemplinic unit (Slovak Republic), after Vozarova (this paper). Zemplinic, Slovak Republic, 21°44'E - 48°30'N.

AUTUNIAN AND SAXONIAN OF THE ZEMPLINIC UNIT

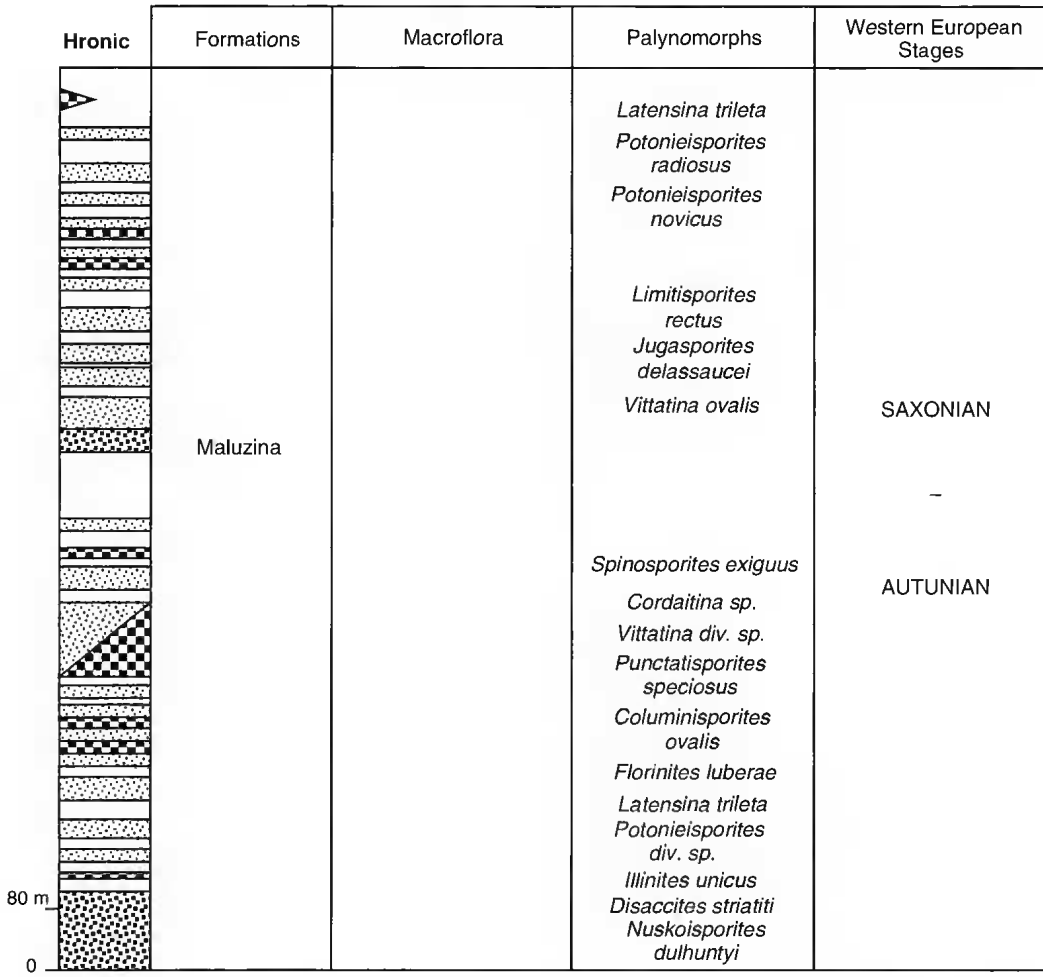


LOG. 22. — Slovak Republic Basins, coordinated by Vozarova. Autunian and Saxonian of the Zemplinic unit (Slovak Republic), after Vozarova (this paper). Zemplinic, Slovak Republic, 21°44'E - 48°30'N.

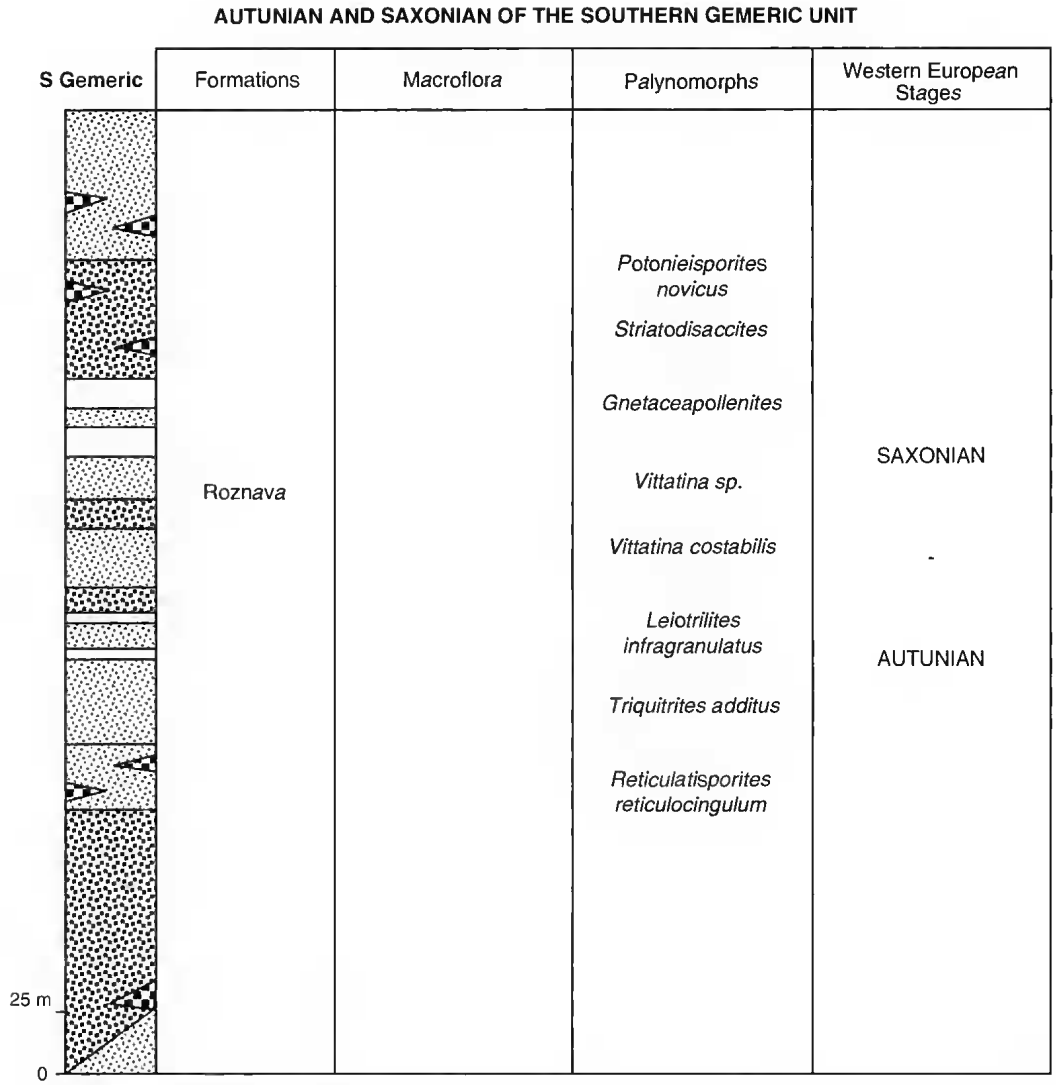


LOG. 23. — Slovak Republic Basins, coordinated by Vozarova. Stephanian of the Hronic unit (Slovak Republic), after Vozarova (this paper). Hronic, Slovak Republic, 19°58'E - 49°03'N.

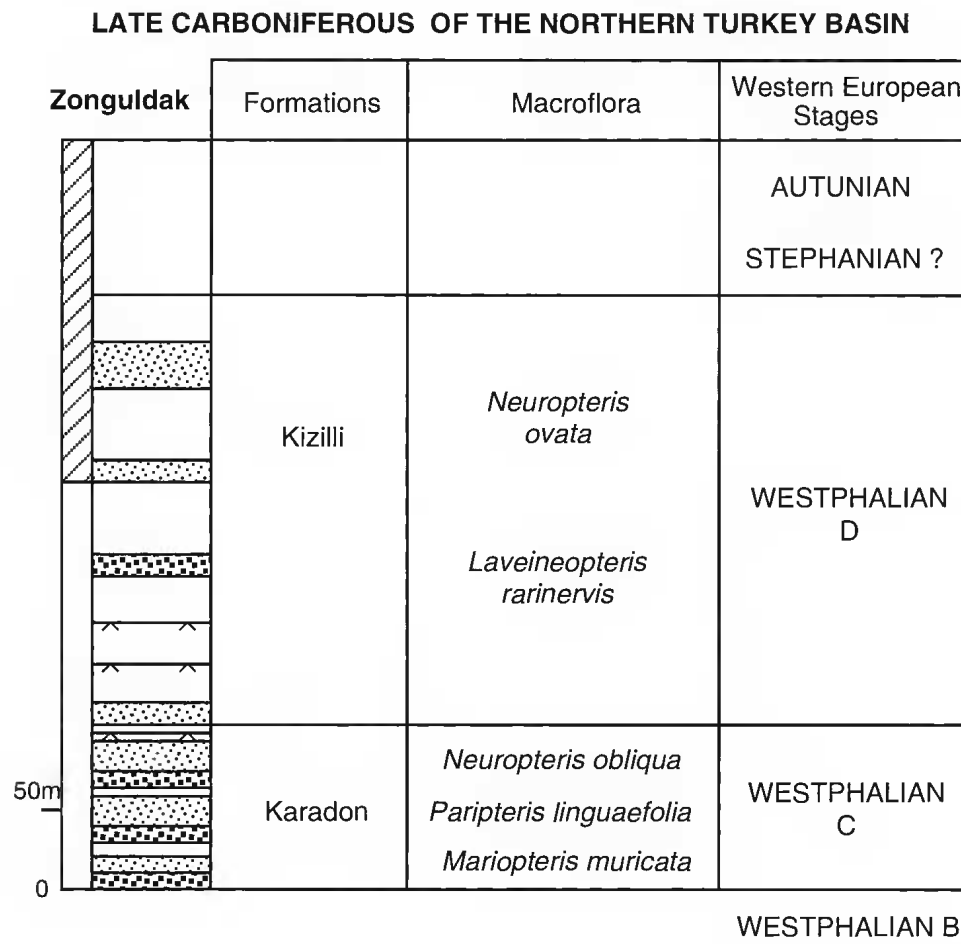
AUTUNIAN AND SAXONIAN OF THE HRONIC UNIT



Log. 24. — Slovak Republic Basins, coordinated by Vozarova. Autunian and Saxonian of the Hronic unit (Slovak Republic), after Vozarova (this paper). Hronic, Slovak Republic, 19°58'E - 49°03'N.

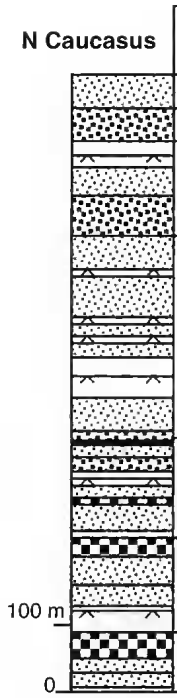


Log. 25. — Slovak Republic Basins, coordinated by Vozarova. Autunian and Saxonian of the southern Gemeric unit, after Vozarova (this paper). Southern Gemeric, Slovak Republic, 20°18'E - 48°40'N.



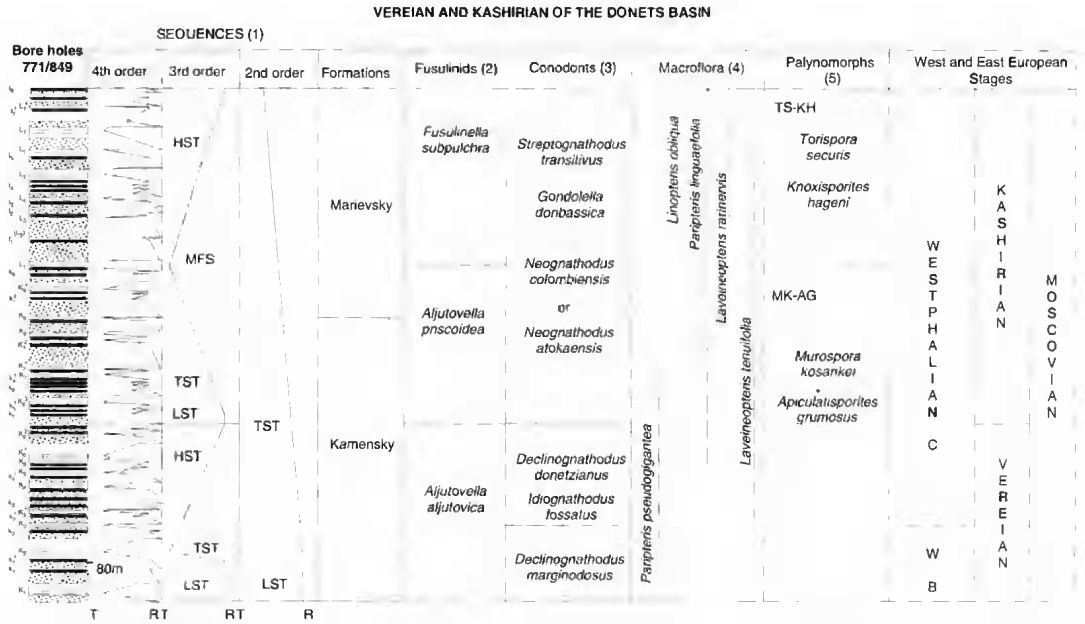
LOG. 26. — Late Carboniferous of the Northern Turkey Basin, coordinated by Izart, Izart (this paper) after Görur *et al.* (1997) and Kerey *et al.* (1985). Zonguldak, North Turkey, 31°30'E - 41°15'N.

LATE CARBONIFEROUS OF THE CAUCASUS BASIN

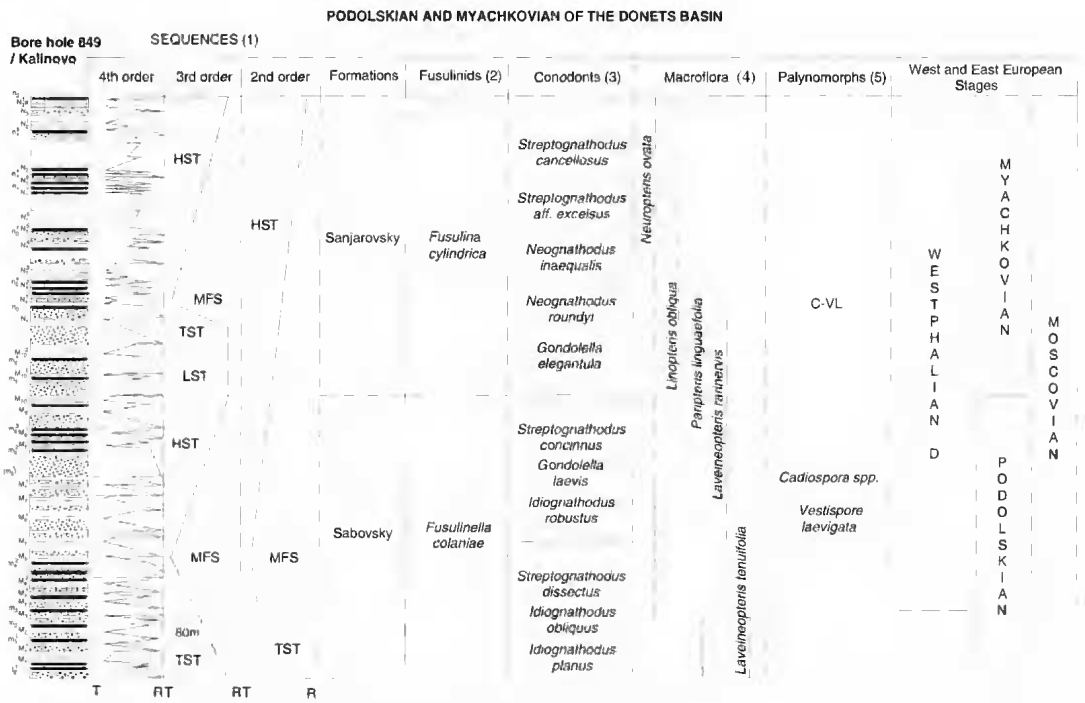


Formations	Macroflora	Western European Stages	Eastern European Stages	
	Walchia piniformis	AUTUNIAN	PERMIAN ? GZHELIAN	
		UPPER STEPHANIAN		
	Asterotheca hemitelioides *Annularia stellata* *Sigillaria brardii*	LOWER STEPHANIAN	KASIMOVIAN	
	Sphenophyllum emarginatum	WESTPHALIAN D	Myachkovian Podolskian	MOSCOVIAN
	Sphenophyllum majus *Linopteris obliqua* *Neuropteris gigantea*	WESTPHALIAN C	Kashirian	
			Vereian	

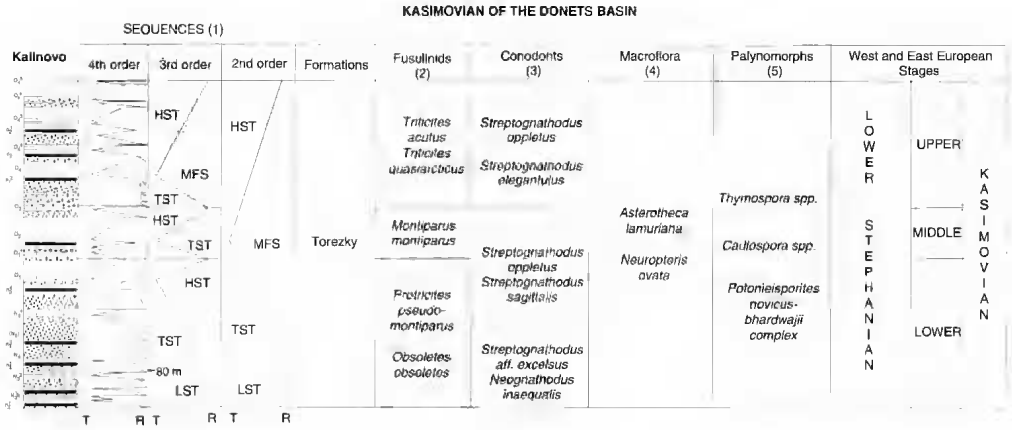
Log. 27. — Late Carboniferous of the Caucasus Basin, coordinated by Izart, Izart (this paper) after Chernyavsky *et al.* (1978). Labinskoe, Russia, 42°E - 44°N.



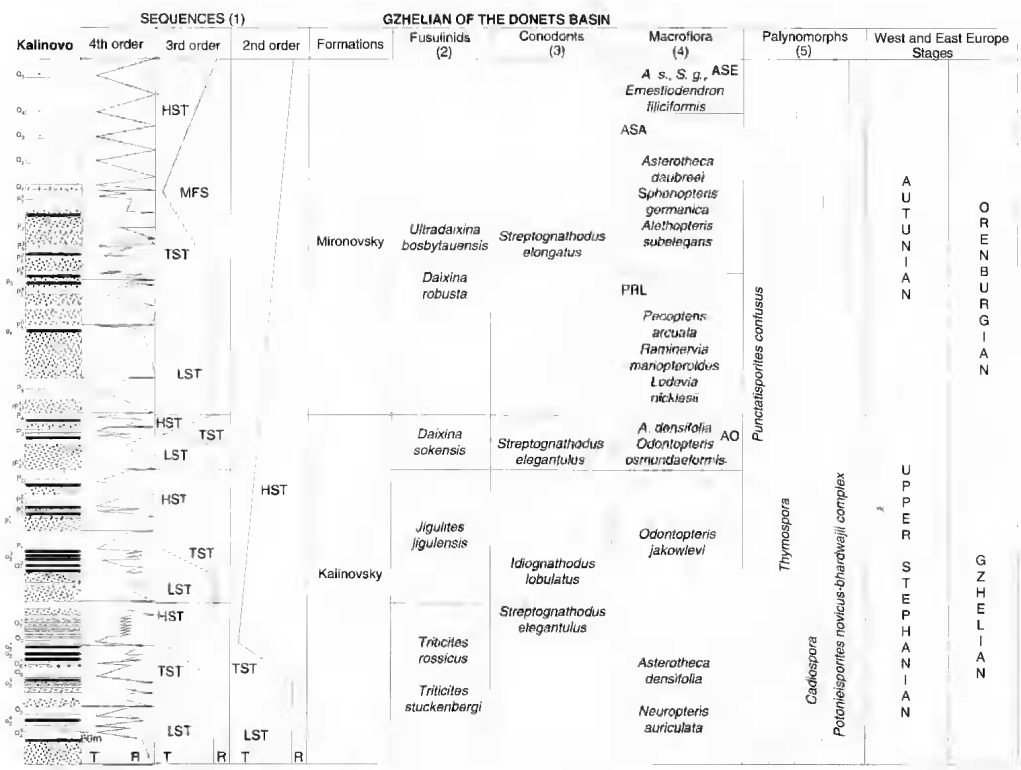
Log. 28. — Donets Basin (Ukraine), coordinated by Izart *et al.* (1996, 1998). Vereian and Kashirian of the Donets Basin. **1**, Izart *et al.* (1996); **2**, Vachard & Maslo (this paper); **3**, Kozitkaya (this paper); **4**, Laveine (this paper); **5**, Coquel (this paper). Boreholes 771/849, 38°30'E - 48°12'N.



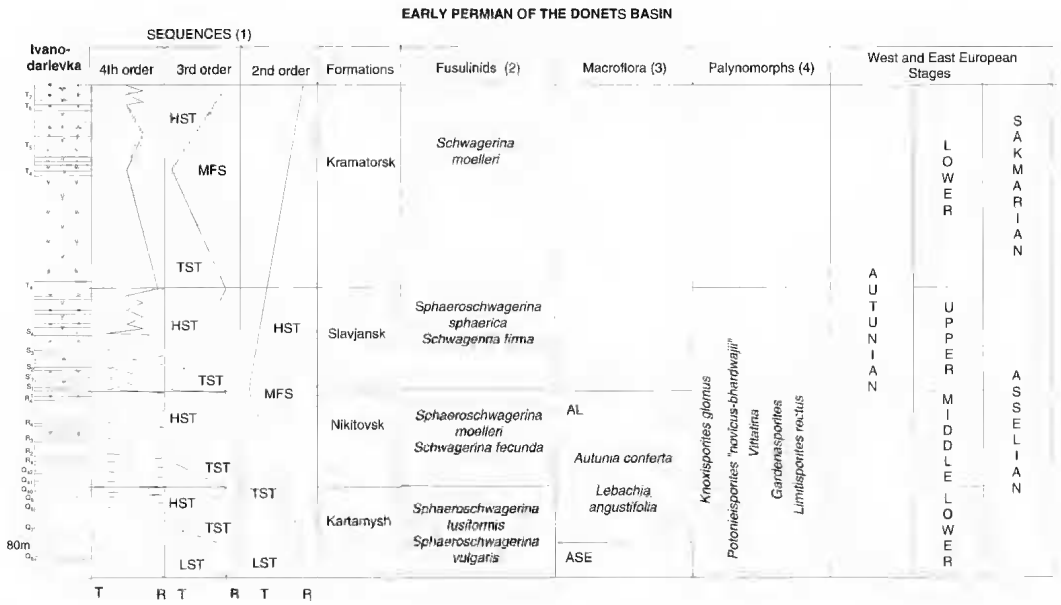
Log. 29. — Donets Basin (Ukraine), coordinated by Izart *et al.* (1996, 1998). Podolskian and Myachkovian of the Donets Basin. **1**, Izart *et al.* (1996); **2**, Vachard & Maslo (this paper); **3**, Kozitkaya (this paper); **4**, Laveine (this paper); **5**, Coquel (this paper). Boreholes 771/849, 38°30'E - 48°12'N.



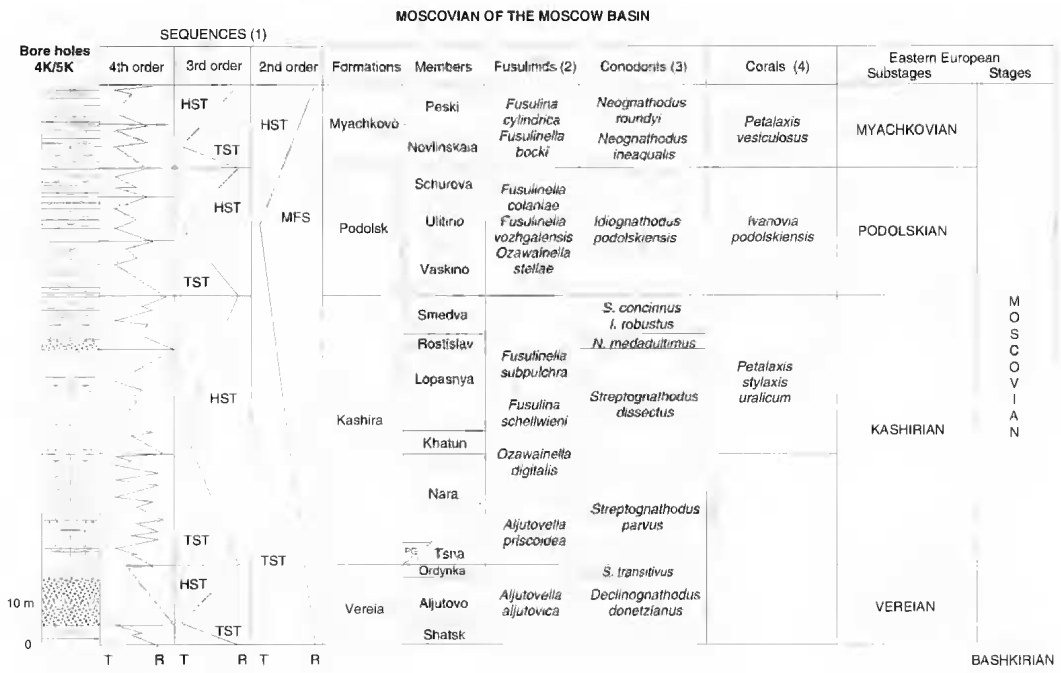
LOG. 30. — Donets Basin (Ukraine), coordinated by Izart *et al.* (1996, 1998). Kasimovian of the Donets Basin. **1**, Izart *et al.* (1996); **2**, Vachard & Maslo (this paper); **3**, Kozitkaya (this paper); **4**, Stchegolev (this paper); **5**, Broutin (this paper). Kalinovo cross-section, 38°48'E - 48°36'N.



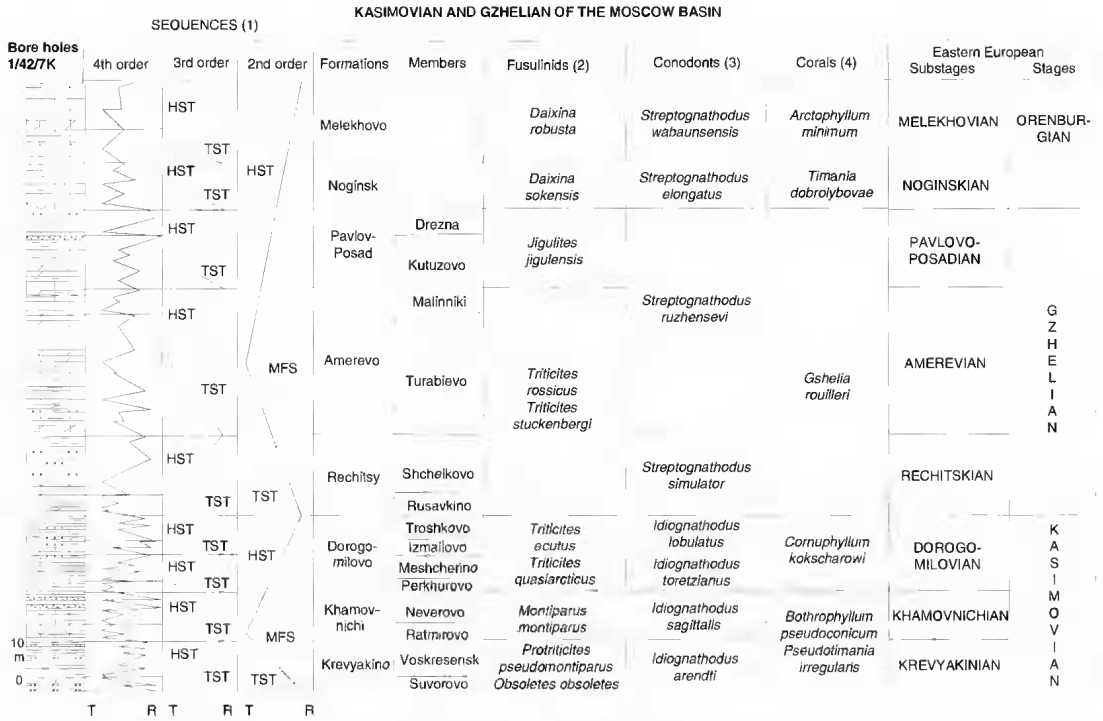
LOG. 31. — Donets Basin (Ukraine), coordinated by Izart *et al.* (1996, 1998). Gzhelian and Orenburgian of the Donets Basin. **1**, Izart *et al.* (1996); **2**, Vachard & Maslo (this paper); **3**, Kozitkaya (this paper); **4**, Stchegolev (this paper); **5**, Broutin (this paper). Kalinovo cross-section, 38°48'E - 48°36'N.



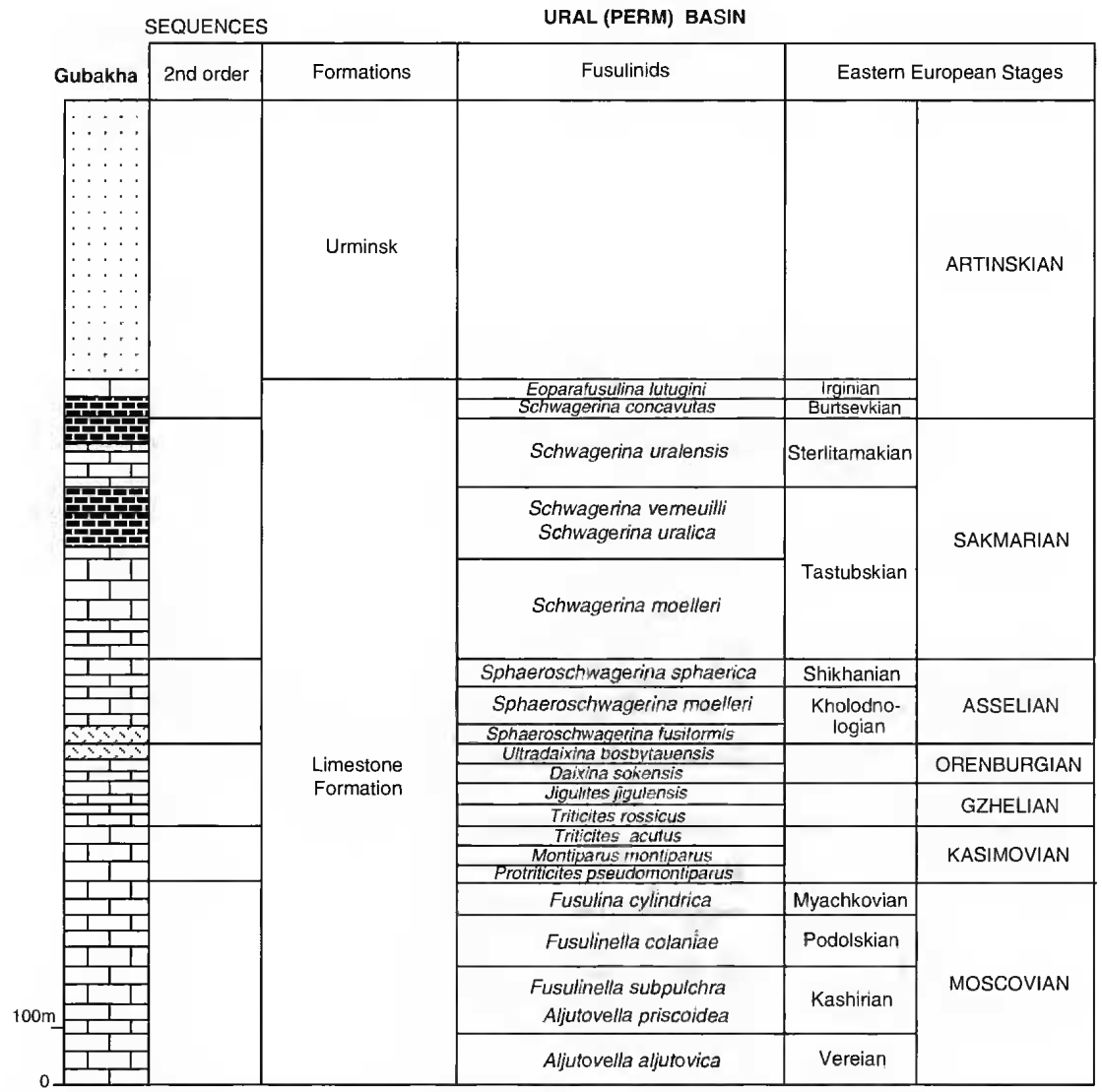
Log. 32. — Donets Basin (Ukraine), coordinated by Izart *et al.* (1996, 1998). Early Permian of the Donets Basin. **1**, Izart *et al.* (1996); **2**, Vachard & Maslo (this paper); **3**, Stchegolev (this paper); **4**, Broutin (this paper). Ivanovo-Darievka cross-section, 37°30'E - 48°30'N.



Log. 33. — Moscow Basin, coordinated by Briand *et al.* Moscovian of the Moscow Basin. **1**, Briand *et al.* (1998); **2**, Makhlina *et al.* (1997); **3**, Goreva (this paper); **4**, Kossovaya (this paper). Borehole 4K, 37°30'E - 55°N; Borehole 5K, 38°E - 55°45'N.

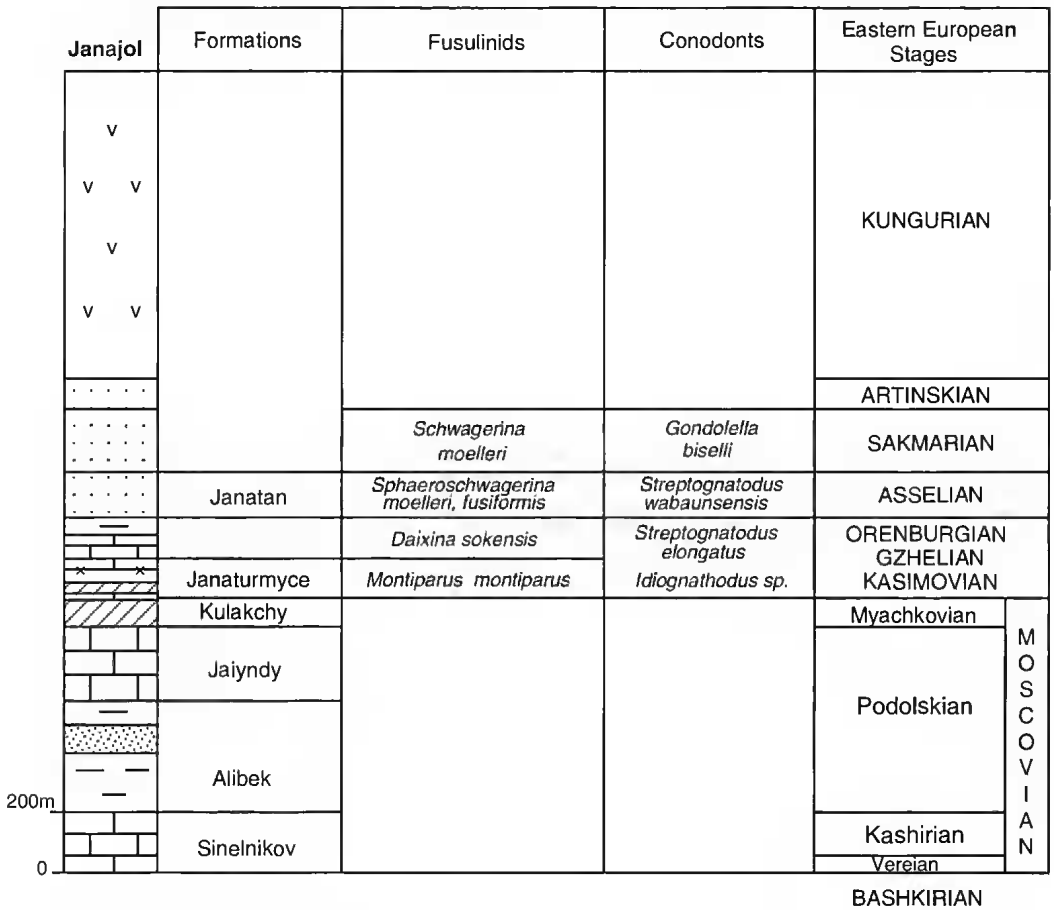


Log. 34. — Moscow Basin, coordinated by Briand *et al.* Kasimovian and Gzhelian of the Moscow Basin. **1**, Briand *et al.* (1998); **2**, Makhlina *et al.* (1997); **3**, Goreva (this paper); **4**, Kossovaya (this paper). Boreholes 1/42, 35°50'E - 56°42'N; Borehole 7K, 38°30'E -56°N.

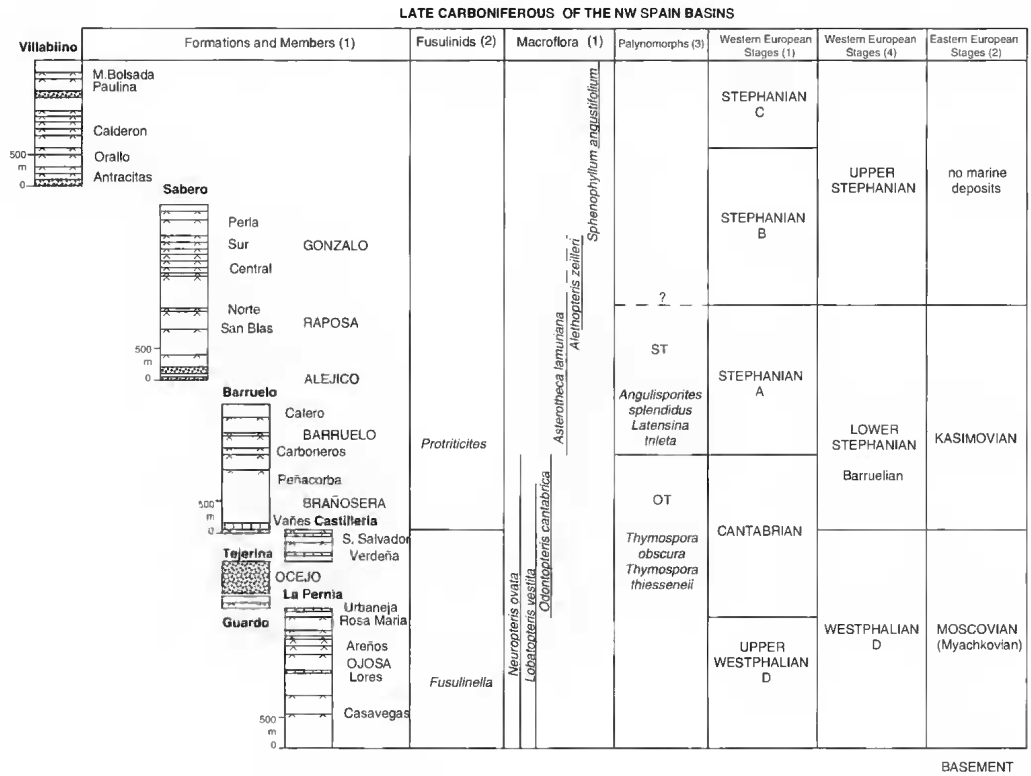


Log. 35. — Moscovian to Artinskian in Central Ural Basin (Perm), coordinated by Izart *et al.*, after Chuvachov (1993). Gubakha, Russia, 57°30'E - 58°50'N.

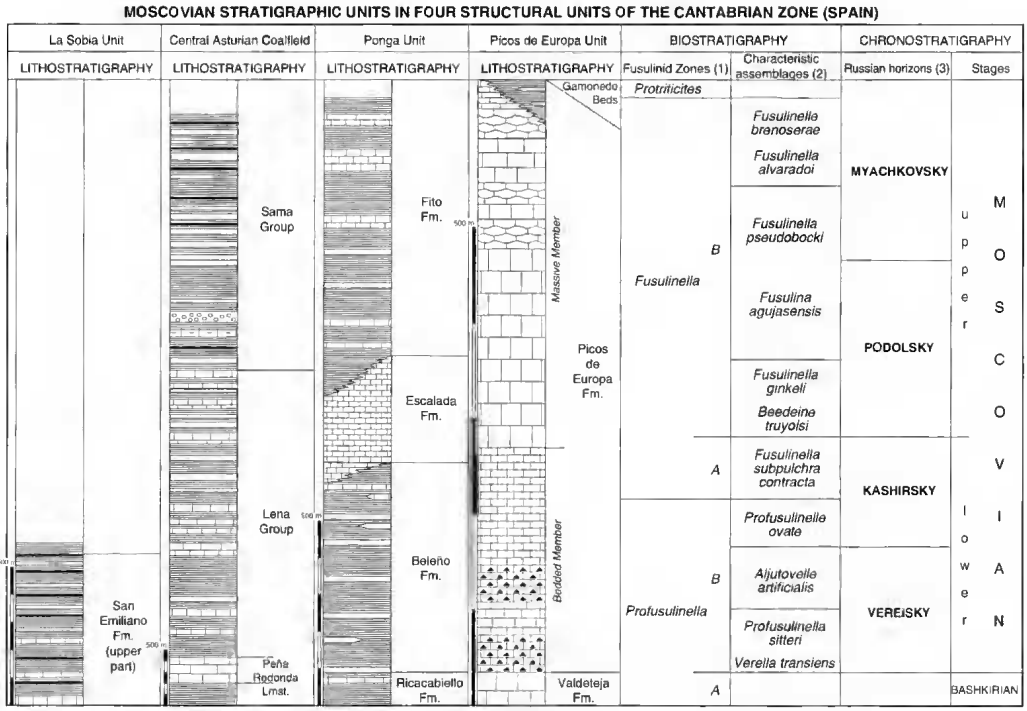
LATE CARBONIFEROUS AND EARLY PERMIAN OF THE EASTERN PRECASPIAN BASIN



Log. 36. — Late Carboniferous and Early Permian of the Eastern Precaspian Basin (Kazakhstan), coordinated by Ensepbaev, after Ensepbaev (this paper). Janajol, Kazakhstan, 57°E - 50°N.

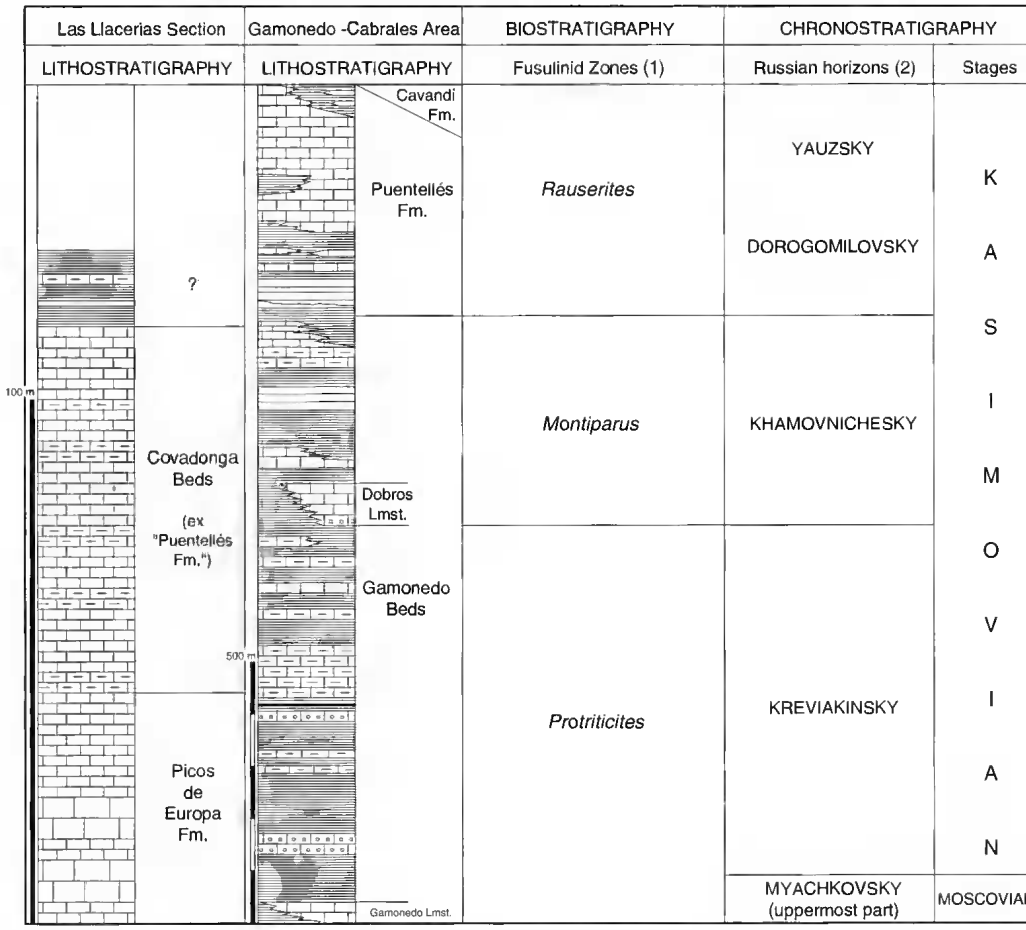


LOG. 37. — Late Carboniferous of northwestern Spain Basins, coordinated by Izart. **1**, Bouroz *et al.* (1972), Wagner & Winkler-Prins (1985); **2**, Lys (1988a); **3**, Coquel (this paper); **4**, this volume. La Pernia, Spain, 4°30'W - 43°N; Guardo, Spain, 4°50'W - 42°53'N; Tejerina, Spain, 5°01'W - 42°55'N; Castilleria, Spain, 4°28'W - 42°56'N; Barruello, Spain, 4°16'W - 42°53'N; Sabero, Spain, 5°10'W - 42°50'N; Villablino, Spain, 6°10'W - 42°58'N.

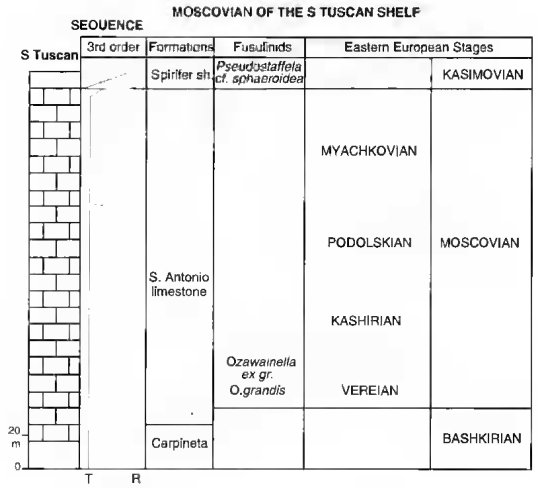


Log. 38. — Cantabrian Basin (Spain), coordinated by Villa. Moscovian stratigraphic subdivisions in four structural units of the Cantabrian zone (Spain). **1**, after van Ginkel (1965); **2**, **3**, Villa (this paper). Mieres, Spain, 5°47'W - 43°16'N.

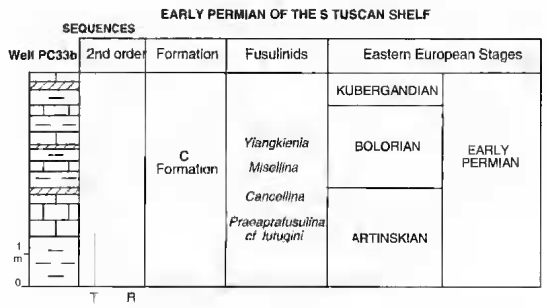
KASIMOVIAN OF THE PICOS DE EUROPA (CANTABRIAN ZONE, SPAIN)



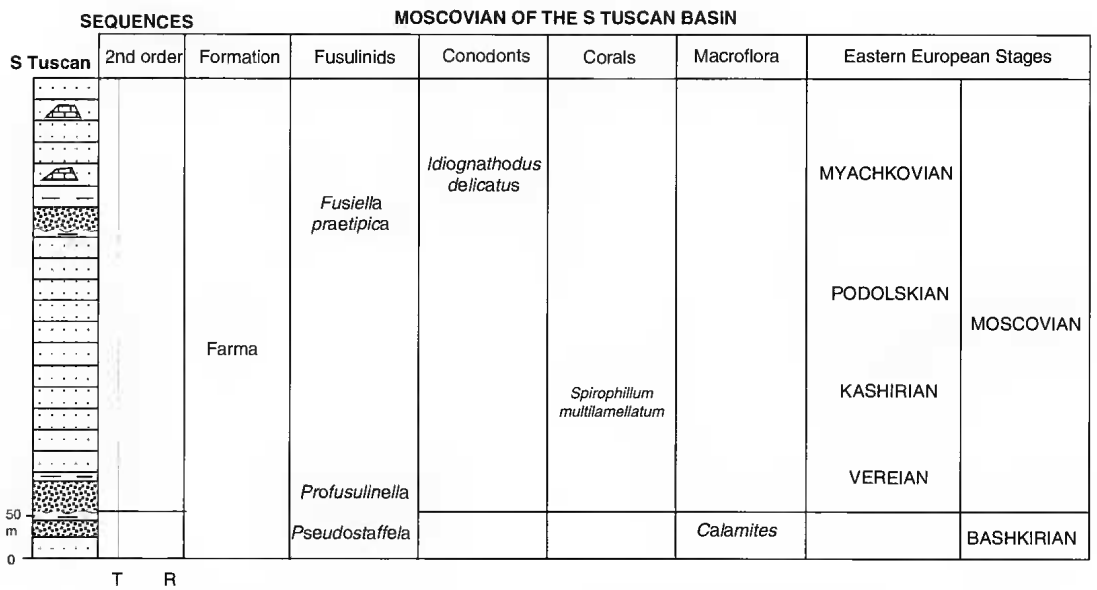
LOG. 39. — Cantabrian Basin (Spain), coordinated by Villa. Kasimovian of the Picos de Europa (Cantabrian zone, Spain). **1**, according to Villa (1985, modified); **2**, Villa (this paper). Picos de Europa, Spain, 4°50'W - 43°15'N.



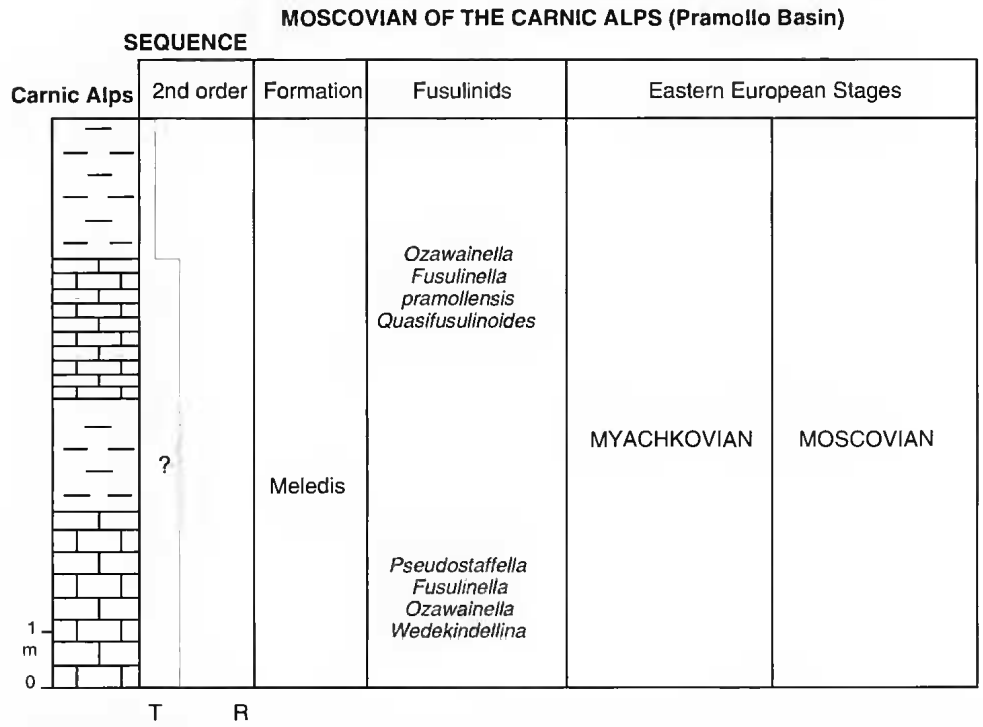
LOG. 40. — Italy Basins, coordinated by Pasini & Vai. Moscovian of the southern Tuscan Shelf, Pasini & Vai (1997).



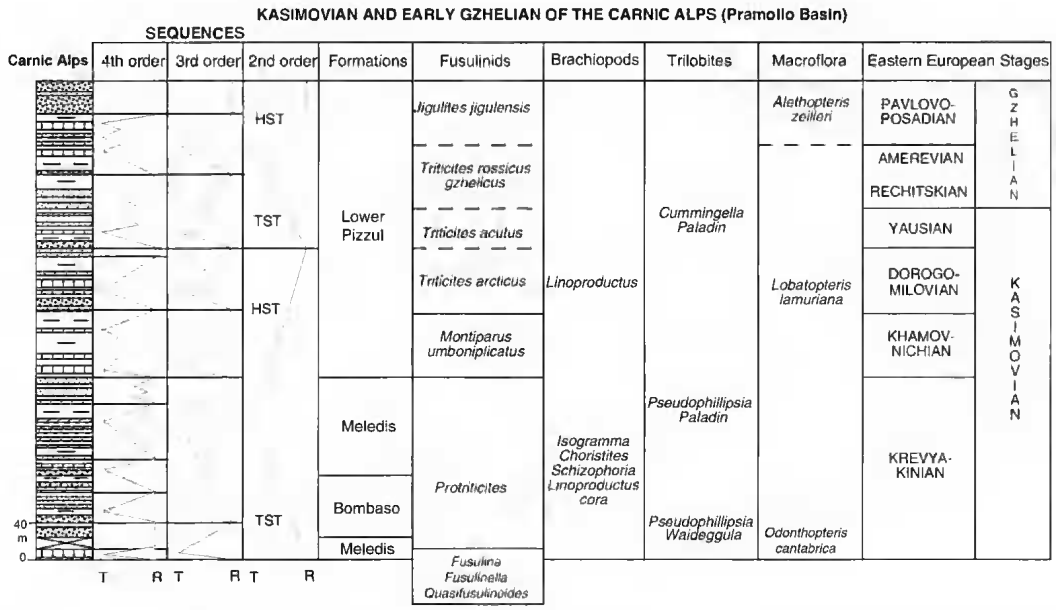
LOG. 41. — Italy Basins, coordinated by Pasini & Vai. Early Permian of the southern Tuscan shelf, Pasini & Vai (1997).



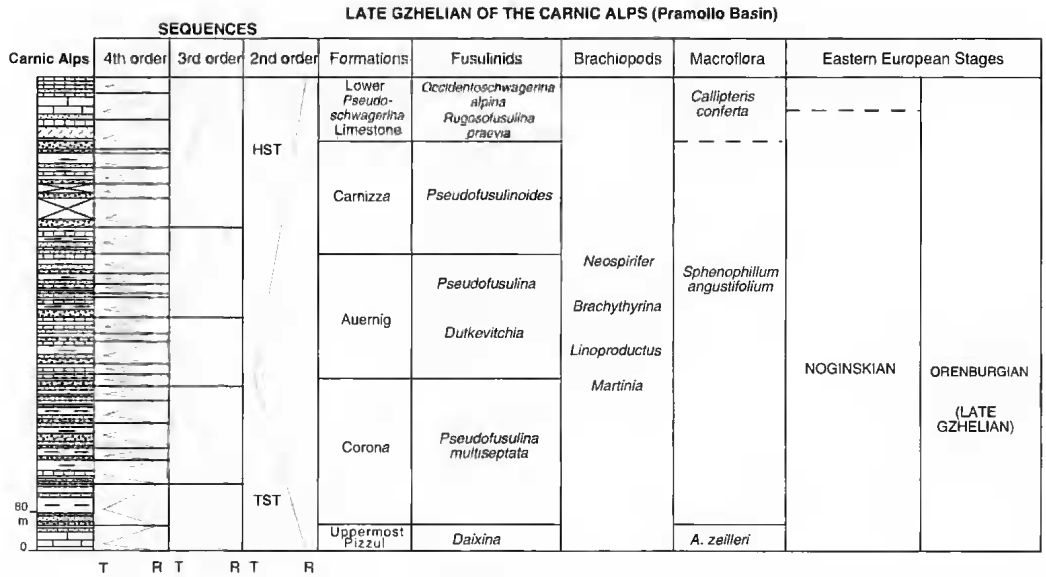
LOG. 42. — Moscovian of the southern Tuscan Basin, Pasini & Vai (1997), Borehole PC33b (Tuscany, Italy).



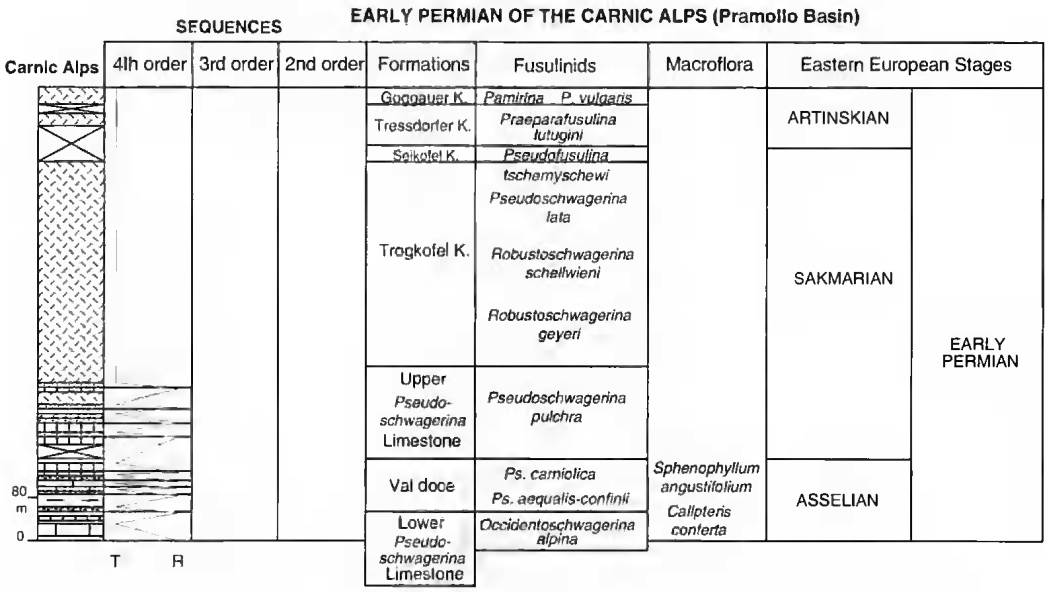
LOG. 43. — Austria boundary, coordinated by Vai, Pasini & Venturi. Moscovian of the Carnic Alps (Pramollo Basin), Pasini (this paper).



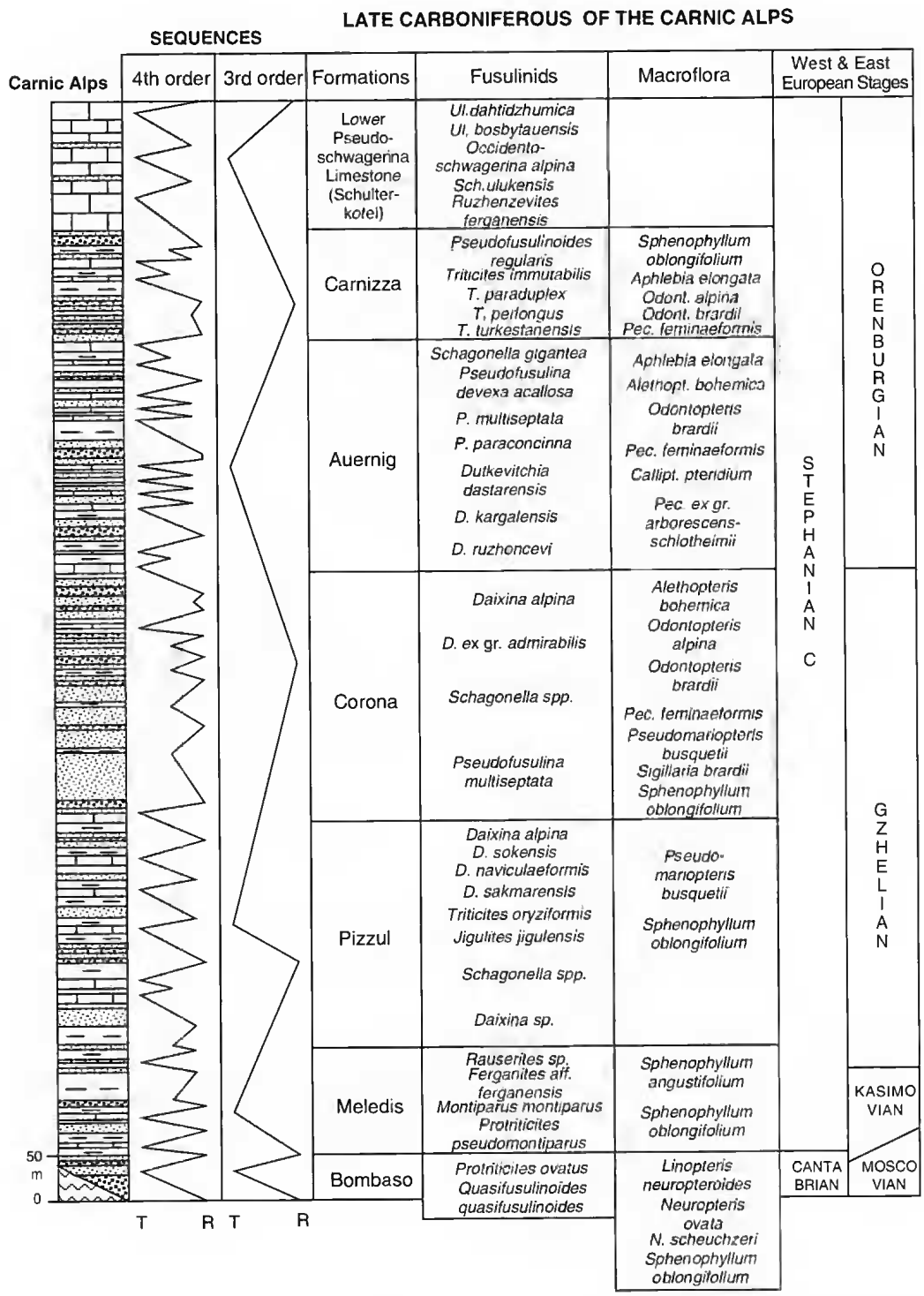
LOG. 44. — Austria boundary, coordinated by Vai, Pasini & Venturi. Kasimovian and early Gzhelian of the Carnic Alps (Pramollo Basin), Vai & Venturi (1997).



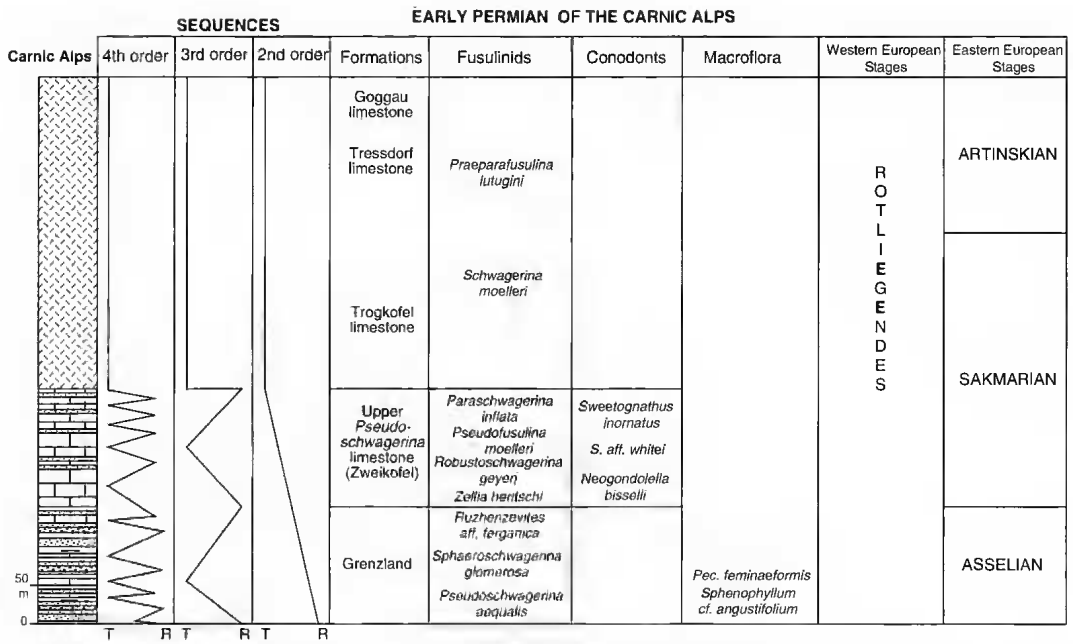
Log. 45. — Austria boundary, coordinated by Vai, Pasini & Venturi. Late Gzhelian of the Carnic Alps (Pramollo Basin), Vai & Venturi (1997).



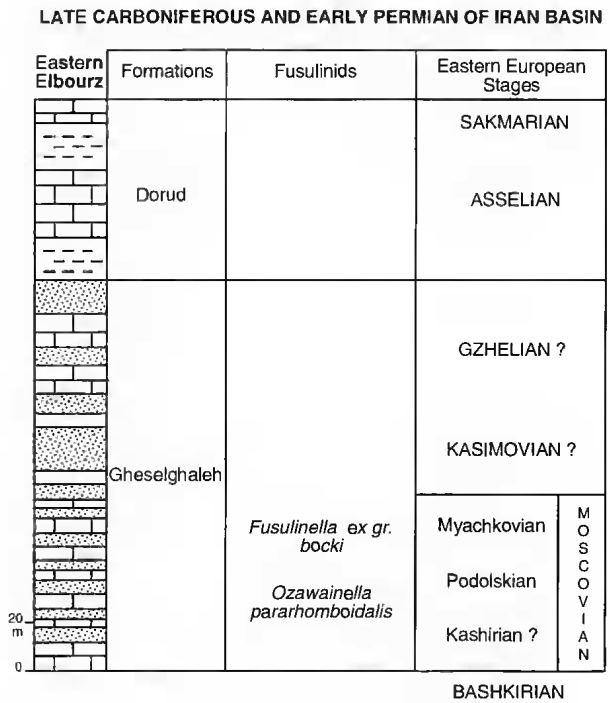
Log. 46. — Austria boundary, coordinated by Vai, Pasini & Venturi. Early Permian of the Carnic Alps (Pramollo Basin), Vai & Venturi (1997).



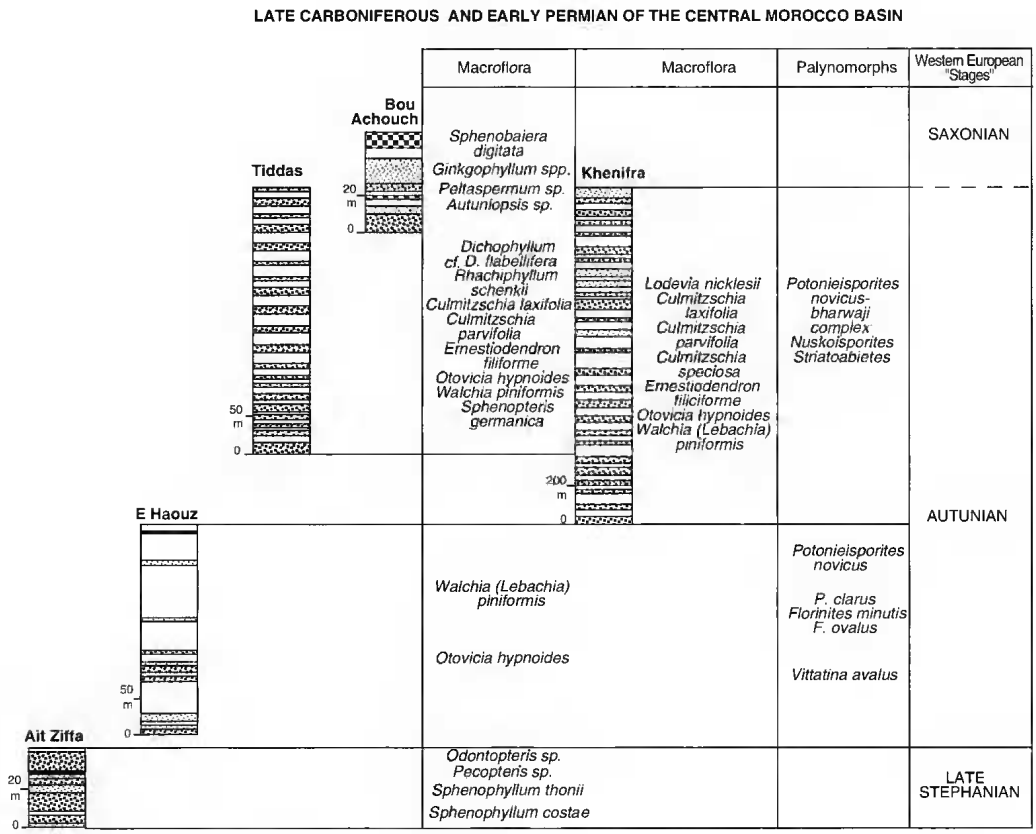
LOG. 47. — Austria boundary, coordinated by Krainer & Davydov. Late Carboniferous of the Carnic Alps, Krainer (this paper).



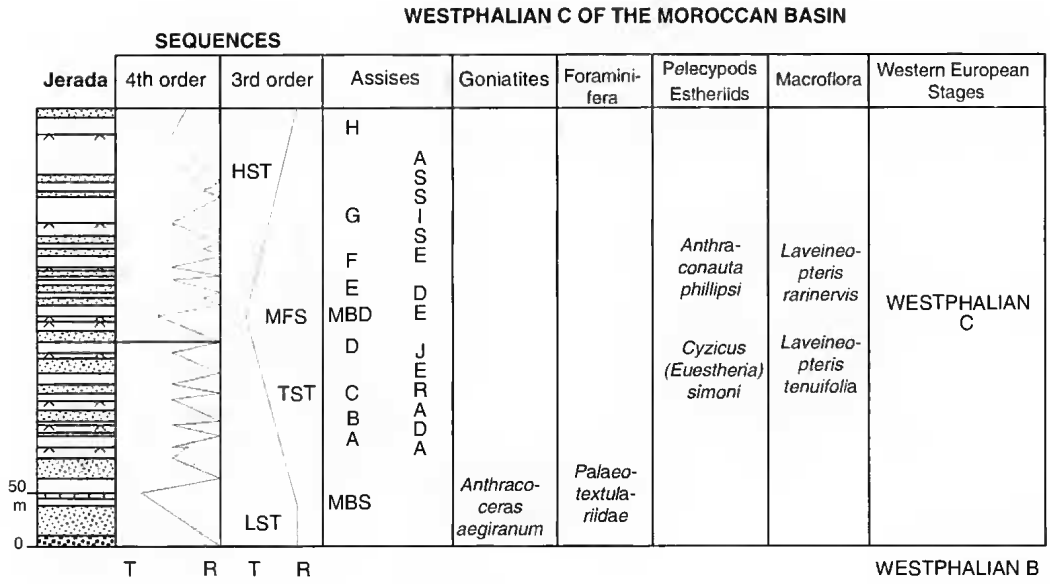
LOG. 48. — Austria boundary, coordinated by Vai, Pasini, Venturi, Krainer & Davydov. Early Permian of the Carnic Alps, Krainer (this paper). Auernig, Carnic Alps, 13°17'E - 46°33'N; Trogkofel, Carnic Alps, 13°13'E - 46°35'N.



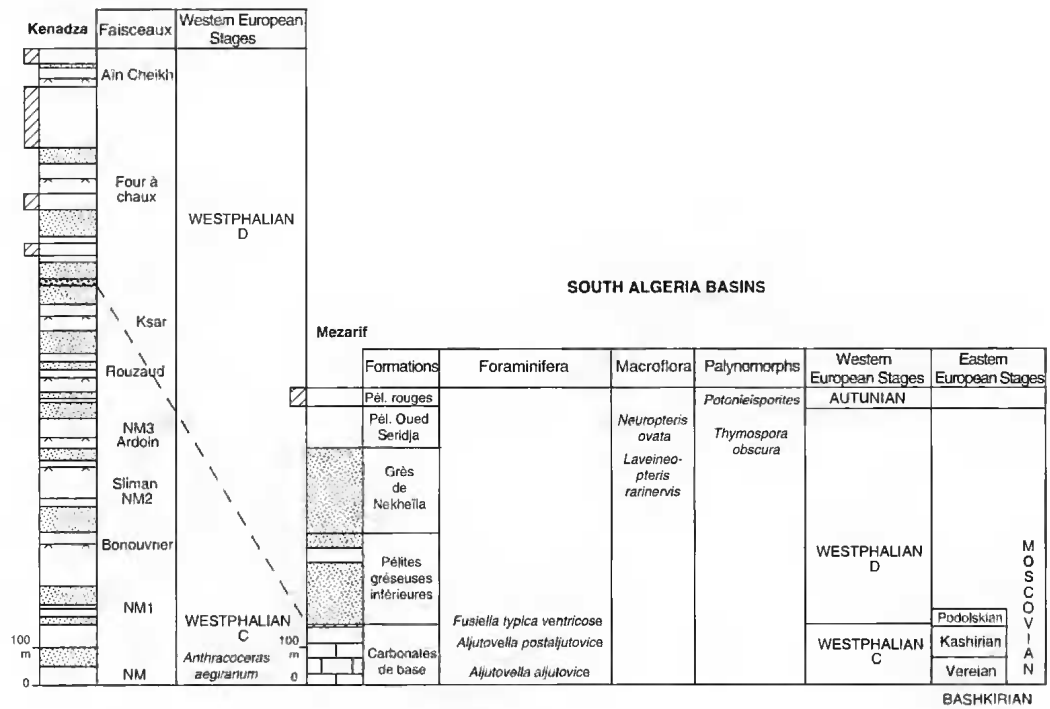
LOG. 49. — Late Carboniferous and Early Permian of eastern Elbourz Basin (Iran), coordinated by Jenny & Jenny-Deshusses, after Jenny & Jenny-Deshusses (this paper). Gheselghaleh, Iran, 53°E - 34°N.



LOG. 50. — Morocco Basins: Late Carboniferous and Early Permian of the Central Morocco Basin, coordinated by El Wartiti and Broutin, after El Wartiti & Broutin (this paper). Ait Ziffa, 7°30'W, 31°27'N; Bou Achouch, 5°44'W, 33°42'N; Khenifra, 5°40'W, 33°N; Tiddas, 6°16'W, 33°34'N; Haouz, 7°10'W, 32°N.

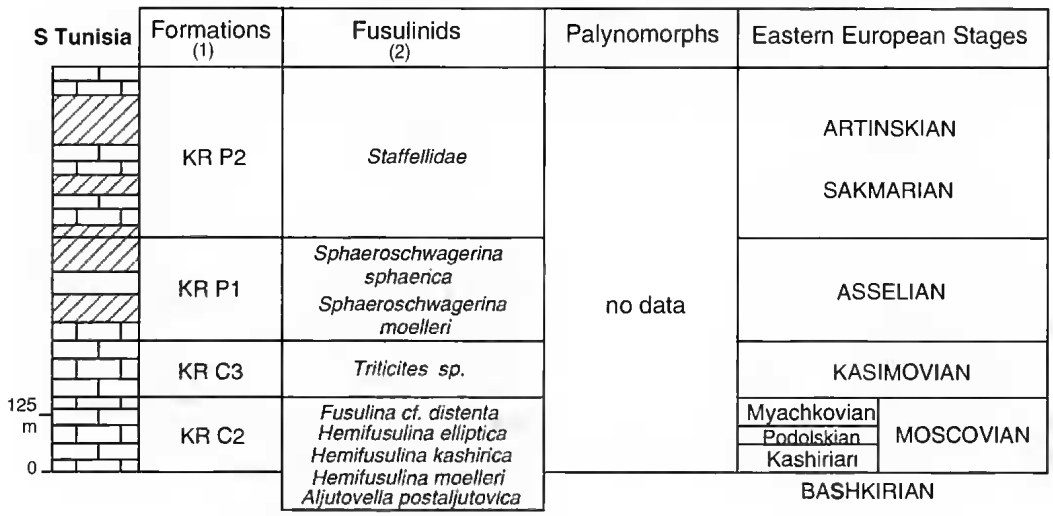


Log. 51. — Morocco Basins: Westphalian of the eastern Morocco Basin, coordinated by Izart, after Izart (this paper). Jerada, 2°W - 34°30'N.



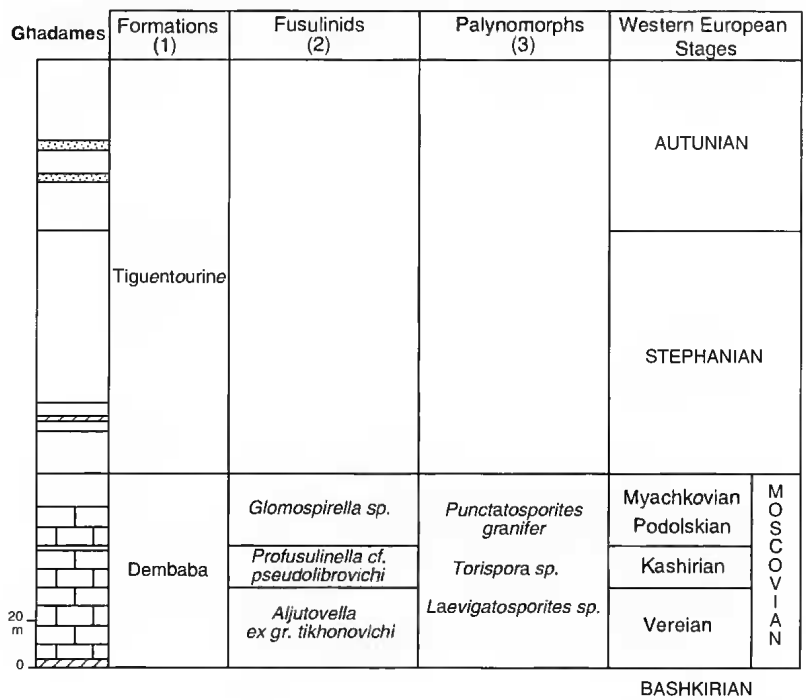
Log. 52. — Westphalian of the southern Algeria Basins, coordinated by Izart, after Nedjari (1982). Kenadza, southern Algeria, 2°W - 31°45'N; Mezarif, Southern Algeria, 1°45'W - 31°45'N.

LATE CARBONIFEROUS AND EARLY PERMIAN OF THE SOUTH TUNISIA BASIN

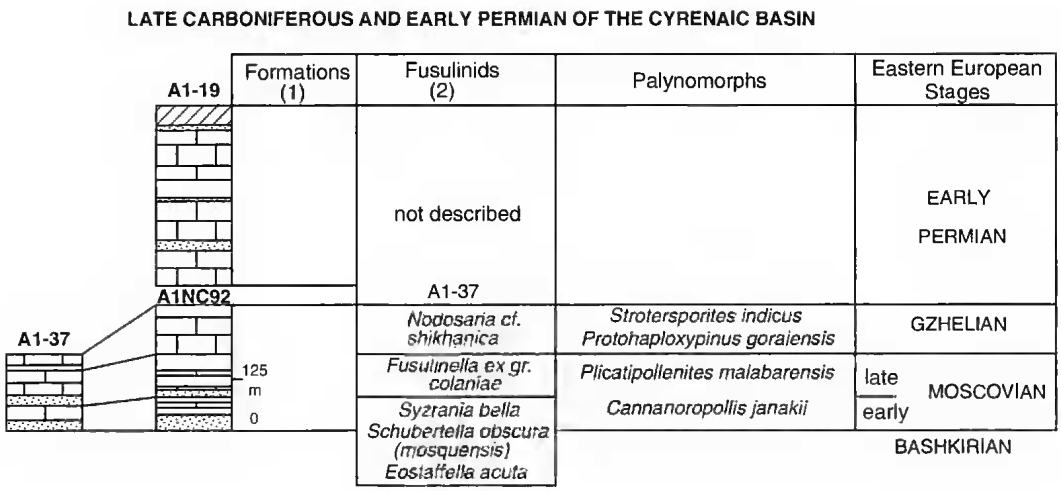


Log. 53. — Late Carboniferous and Early Permian of the southern Tunisia Basin, coordinated by Massa and Lys. **1**, Massa (this paper); **2**, Lys (this paper). Kirchaou, 10°40'E - 33°N.

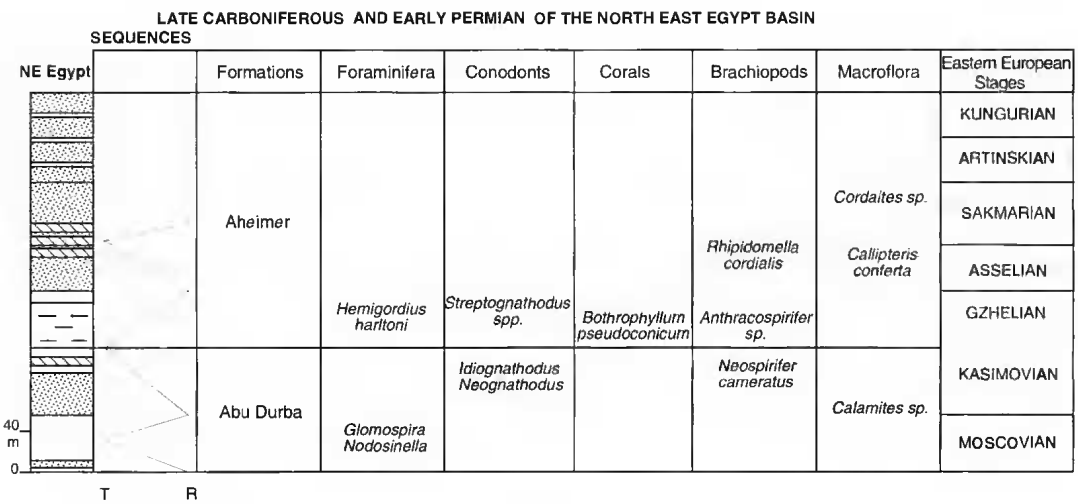
LATE CARBONIFEROUS AND EARLY PERMIAN OF THE GHADAMES BASIN



Log. 54. — Libya Basins, coordinated by Massa, Vachard and Coquel. Late Carboniferous and Early Permian of the Ghadames Basin (Libya). **1**, Massa (this paper); **2**, Vachard (this paper); **3**, Coquel (this paper). Ghadames, Libya, 10°30'E - 29°N.

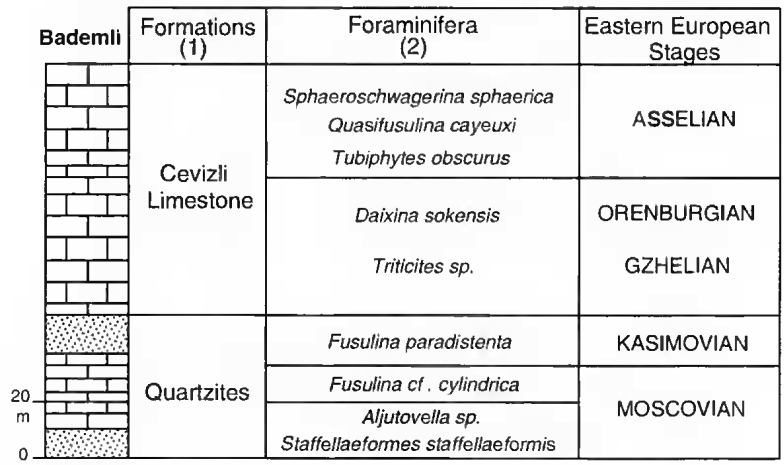


Log. 55. — Libya Basins, coordinated by Massa, Vachard and Coquel. Late Carboniferous and Early Permian of the Cyrenaic Basin (Lybia). **1**, Massa (this paper); **2**, Vachard *et al.* (1993). A1-37 borehole:), 22°53'E - 30°44'N; A1NC92 borehole, 22°08'E - 31°N; A1-19 borehole, 23°40'E - 31°N.



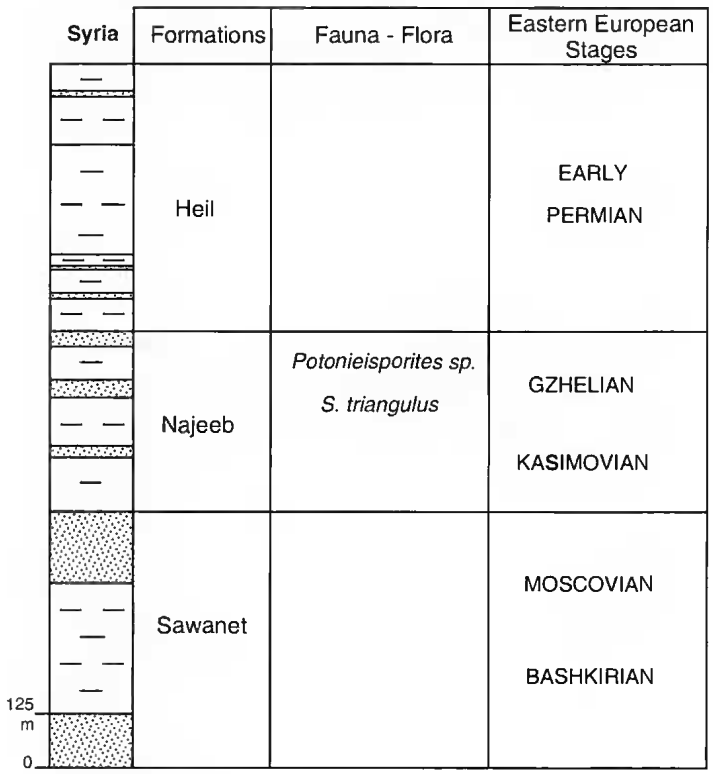
Log. 56. — Late Carboniferous and Early Permian of the northeastern Egypt Basin, coordinated by Kora, after Kora (1995). Abu Durba, Egypt, 33°18'E - 28°35'N; Wadi Aheimer, Egypt, 32°23'E - 29°30'N.

LATE CARBONIFEROUS AND EARLY PERMIAN OF SOUTHERN TURKEY



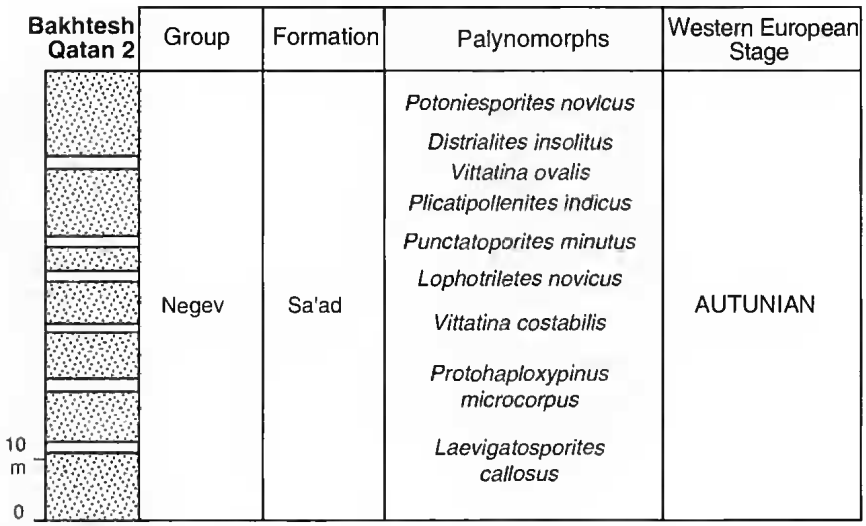
LOG. 57. — Late Carboniferous and Early Permian of the southern Turkey, coordinated by Monod. **1**, Monod (1977); **2**, Lys (1988). Bademli, southern Turkey, 32°E - 37°30'N.

LATE CARBONIFEROUS AND EARLY PERMIAN OF SYRIA



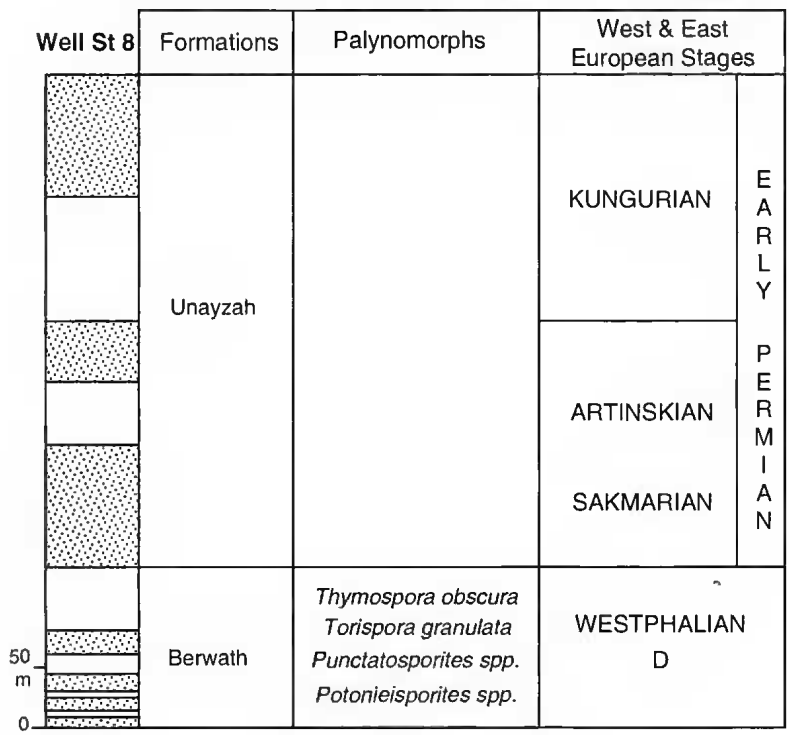
LOG. 58. — Late Carboniferous and Early Permian of Syria, coordinated by Izart, after Al Youssef & Ayed (1992). Sawanet 2, Syria, 38°E - 34°10'N.

PERMIAN OF ISRAEL BASIN

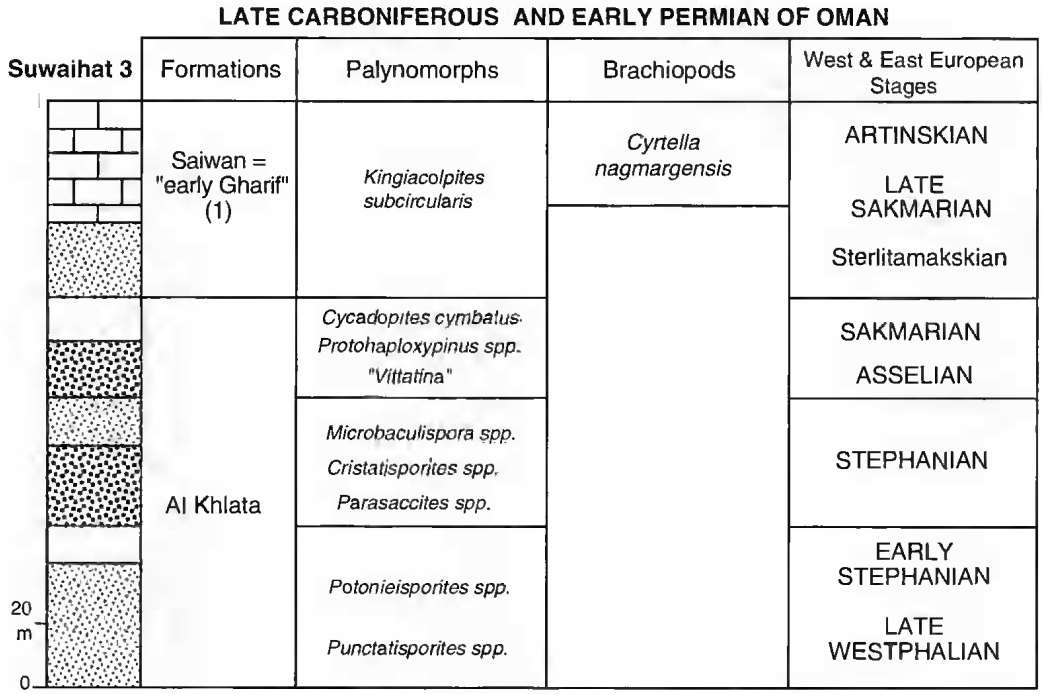


Log. 59. — Permian of Israel Basin, coordinated by Weissbrod, after Weissbrod (this paper). Well Bakhtesh Qatan 2, 35°E - 31°N.

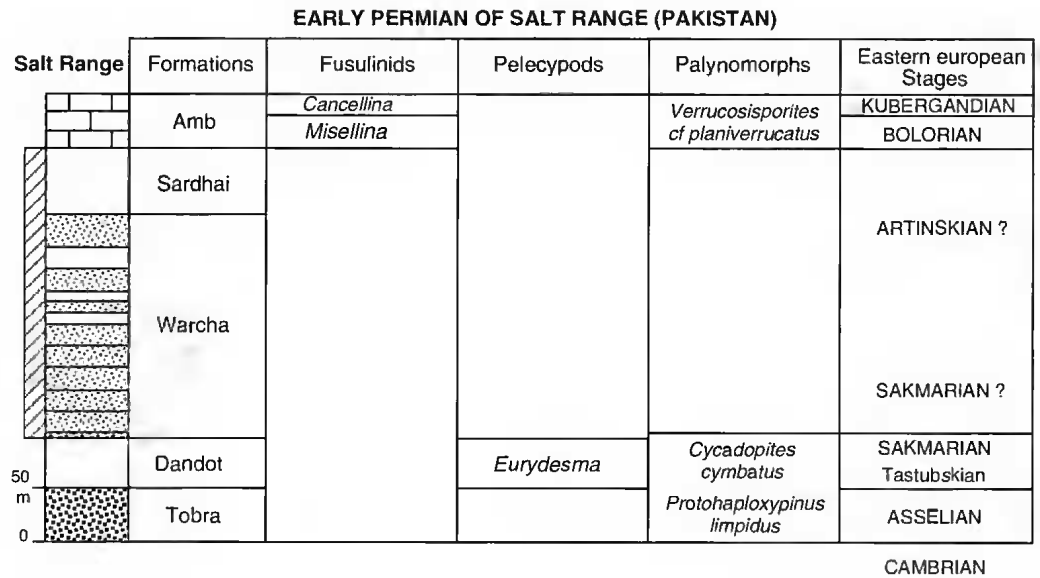
LATE CARBONIFEROUS AND EARLY PERMIAN OF SAUDI ARABIA



Log. 60. — Late Carboniferous and Early Permian of Saudi Arabia, coordinated by Izart and Vaslet, after Owens & Turner (1995) and Al Laboun (1993). Well 8, Saudi Arabia, 42°E - 30°N.



Log. 61. — Late Carboniferous and Early Permian of Oman, coordinated by Izart and Vaslet, after Broutin *et al.* (1995) and Angiolini *et al.* (1997); **1**, Saiwan = ex "early Gharif" *sensu* Love (1994). Well Suwaihat 3, 55°E - 20°N.



Log. 62. — Early Permian of Salt Range Basin (Pakistan), coordinated by Iqbal *et al.*, after Iqbal (this paper). Salt Range, 72°E - 32°N.

APPENDIX 2

(1) Laboratoire de Géologie des Ensembles Sédimentaires, Université de Nancy I, B.P. 239, F-54506 Vandœuvre-les-Nancy (France)
(2) BRGM-SGN, B.P. 6009, F-45060 Orléans cedex 2 (France)
(3) Laboratoire de Paléobotanique, Université Pierre-et-Marie-Curie, 12 rue Cuvier, F-75252 Paris cedex 05 (France)
(4) Laboratoire de Palébotanique, Université des Sciences et Technologies Lille I, F-59655 Villeneuve d'Ascq (France)
(5) Department of Geosciences, Boise State University, 1910 University Drive, Boise, Idaho 83725 (USA)
(6) Faculté des Sciences, Département des Sciences de la Terre, Université Mohammed V, Avenue Ibn Batouta, B.P. 1014, Rabat (Morocco)
(7) Faculté du Pétrole, département de Géologie du Pétrole et du Gaz, Institut polytechnique Kazakh, 22 rue Satpaev, 480013 Almaty (Kazakhstan)
(8) Geological Survey, PO Box 157, 2000 AD Haarlem (The Netherlands)
(9) Geological Institute of the Academy of Sciences of Russia, 7 per. Pyzhevsky, Moscow 109117 (Russia)
(10) Madem Fakultesi, Jeoloji Bölümü, Tubitak-Glotek, ITU, Ayazaga, 80626, Istambul (Turkey)
(11) Pakistan Museum of Natural History, 7/2 Islamabad (Pakistan)
(12) All-russian Research Geological Institute (VSEGEI), Sredny pr. 74, Saint Petersburg (Russia)
(13) Institut für Geologie und Paläontologie der Universität Innsbrück, Innrain 52, A-6020 Innsbrück (Austria)
(14) Industrial Geological Amalgamation, Tsenter Geology, 39a, Warshawshoye Shosse, Moscow (Russia)
(15) Institute of Geological Sciences, Ukraineian Academy of Sciences, 55b Chkalov Street, Kiev, 252601 (Ukraine)
(16) Faculty of Sciences, Department of Geology, University of Mansoura, Mansoura 35516 (Egypt)
(17) 6 rue J.-J.-Rousseau, F-92150 Suresnes (France)
(18) École des mines de Paris, CGES-sédimentologie, 35 rue Saint-Honoré, F-77305 Fontainebleau cedex (France)
(19) Département des Sciences de la Terre, Université d'Orléans, B.P. 6759, F-45067 Orléans 2 (France)
(20) Department of Geology, Charles University, Albertov 6, 128 43 Praha 2 (Czech Republic)
(21) Institute of Geology, Department of Paleontology, Freiberg University of Mining and Technology, Bernhard von Cotta Str. 2, D-09596 Freiberg (Germany)
(22) Geologische Bundesanstalt, postfach 154, A-1031 Wien (Austria)
(23) Geologisches Institut, Nussalle 8, D-53757 Bonn (Germany)
(24) Dipartimento di Scienze geologiche, Universita degli studi di Bologna, 67 via Zamboni, I-40127 Bologna (Italy)
(25) Geological Survey, Mlynska dolma 1, 81704 Bratislava (Slovak Republic)
(26) Geological Survey, 30 Malkhe Israel Street, Jerusalem 95501 (Israel)
(27) Polish Geological Institute, Late Silesian branch, Sosnowiec (Poland).

Stratigraphy, palaeoclimatology and palaeogeography of the Late Palaeozoic continental deposits in the Czech Republic

Stanislav OPLUŠTIL
Department of Geology and Palaeontology, Faculty of Science,
Charles University, Albertov 6,
128 43 Praha 2 (Czech Republic)
oplustil@mail.natur.cuni.cz

Jiří PEŠEK
Department of Geology and Palaeontology, Faculty of Science,
Charles University, Albertov 6,
128 43 Praha 2 (Czech Republic)

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ABSTRACT

Numerous Late Palaeozoic continental basins were formed within the territory of the Czech Republic. Their sedimentary history began either in the Westphalian (central and western Bohemia, Brandov Basin and basins in Sudetic area) or in the late Stephanian (Blanice and Boskovice Grabens). The incompleteness of the floral record gives an evidence for several hiatuses the most important of which are those between the Bolsovian and Westphalian D and between the Stephanian B and C. During the deposition, an increase in sedimentary area, structural reworking and also considerable changes in source areas took place.

KEY WORDS
Peri-Tethys
Bohemian Massif,
Late Carboniferous,
Westphalian,
Stephanian,
Autunian,
continental basins,
palaeogeography.

RÉSUMÉ

La stratigraphie, la paléoclimatologie et la paléogéographie des dépôts continentaux du Paléozoïque supérieur de Bohème (République Tchèque). De nombreux bassins continentaux d'âge paléozoïque supérieur se sont formés sur le territoire de la République Tchèque. Leur histoire commence soit dans le Westphalien (Bohème centrale et occidentale, bassins de Brandov et des Sudètes) soit dans le Stéphanien supérieur (grabens de Blanice et de Boskovice). On n'y trouve pas toutes les biozones de paléoflore, ce qui montre la présence de plusieurs hiatus, dont les plus importants sont ceux entre le Bolsovien et le Westphalien D et entre le Stéphanien B et C. Pendant le dépôt, on note une augmentation de l'aire de sédimentation et du remaniement structural et aussi des changements considérables dans les sources d'apport.

MOTS CLÉS
Péri-Téthys
massif bohémien,
Carbonifère supérieur,
Westphalien,
Stéphanien,
Autunien,
bassins continentaux,
paléogéographie.